SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1900.

GENERAL PHYSICS.

1. *Measurement of Small Elongations.* **G. Ercolini.** (N. Cimento, 10. pp. 241–263, October, 1899.)—Three different methods are described. The first is based upon the measurement of a very small liquid resistance in the gap to be measured, which is introduced as one branch of a Wheatstone bridge arrangement. To avoid polarisation the current is made alternating. In the second method three electrodes are immersed in a solution of sulphate of zinc. Two of them are fixed, and the third, mounted between the other two, is subjected to the small displacement to be measured. The redistribution of the fall of potential is compensated by shifting a corresponding terminal along a straight wire. The third method is non-electrical. A weight is suspended by a bifilar suspension, without freedom of rotation. A small horizontal plate of micra is attached to the middle of the fibres, carrying two magnetic needles and a vertical mirror. When the weight is raised by a slight displacement the needles and the mirror are capable of rotating in a horizontal plane, and will rotate in a suitable magnetic field to an extent depending upon the small displacement. The author uses silk threads for the suspension, and measures distances down to 0·005 mm. E. E. F.

2. *Elasticity of Cement.* **W. L. Brown.** (Instit. Civ. Engin., Proc. 137. pp. 402–409, August, 1899.)—This paper describes researches on the coefficient of direct elasticity of cement and cement mortars, its variation with different kinds and proportions of sand, and with age. The experiments were made on beams 24 inches and 36 inches long, and the deflections under loads were observed with a Ewing extensometer.

The extension is not proportional to the load. A function B is found in the same way as Young's modulus for other materials, *i.e.*, from the formula $B=\frac{WL}{48ID}$, where W = the increase of load from one point to the next, D the increase of deflections corresponding to this small increase of load; B is therefore the average value of the coefficient of direct elasticity for a variation of load of 1 lb. at that point of the load curve. The value of B for neat cements is greater than for cement mortar, is less as the proportion of sand is greater, and increases with age to a considerable extent. Thus, for neat cement one week old, B=1,850,000 lbs. per square inch, six months old, B=2,800,000 lbs. per square inch. A. S.

3. *Uniform Stress and Permanent Strain in Annealed Copper.* **G. Wilson.** (Manchester Lit. and Phil. Soc., Mem. 48. pp. 1–18, 1899.)—T. E. Stanton showed that the stress in iron varied as the fourth root of the permanent strain. The author's experiments are on copper bars, $\frac{3}{8}$ in. diam., 12 in. long, and bring out the fact that in this case the stress varies approximately as the square root of the strain. In one set of experiments each bar operated upon was rapidly subjected to a prearranged load, it was then allowed to stand under this load for a period of thirty minutes, after which the diameter and extension were measured. The stress-strain diagrams obtained differ from those usually drawn by automatic recording instruments. The manner of carrying out the experiments is described.

If P is the load, e the strain due to P, and A the original area, then the stress on the reduced section is $\frac{\mathrm{P}}{\mathrm{A}}(1+e)$. A relation $f=\mathrm{C}e^n$ is assumed, e being the permanent strain and C a constant. The values of n were found from logarithmic plottings, and the values of C calculated, and the relation $f=87{\cdot}91e^{\cdot 524}$ obtained. The formula $f=\frac{\mathrm{C}e^n}{1+e}$ represents the corresponding stress per unit of original area, and by differentiating, the maximum value of this stress occurs when $e=\frac{n}{1+n}$. For annealed copper the corresponding value of e is 1·101 when n is 0·524, that is 110 per cent., while the corresponding value for iron and steel is 33·3 per cent. The maximum stress for annealed copper should therefore be 18·98 tons per square inch of original area. On testing a bar of annealed copper on the same rod as the previous ones the maximum stress was only 15·5 tons per square inch, with an elongation of 80·8 per cent. Thus, while in iron the theoretical maximum load is actually passed, in copper the theoretical elongation is never reached, and consequently the theoretical maximum stress is not reached.

To obtain a complete diagram before and after the yield point a series of copper wires 20 inches long were tested somewhat beyond the elastic limit. Each wire after fixing was stretched by loading and then carefully annealed. After the test was concluded the wire was reannealed and stretched several times, and again retested. The first test shows irregularities in the elastic portion and that the yield point is not definite, the elastic portion curving into the plastic portion. The test after reannealing shows that the irregularities in the elastic part have disappeared, and that the elastic and plastic portions of the logarithmic curve form two straight lines; further, that the yield point is quite definite and corresponds to a stress of 0·715 tons per square inch. So far as these experiments were carried, repeated annealing and straining have the effect of lowering the yield stress and increasing the value of n, but the author was not able to determine how far the lowering of the elastic limit would continue with further strainings. A. S.

4. *Elastic Stability of Long Beams.* **A. G. M. Michell.** (Phil. Mag. 48. pp. 298–309, September, 1899.)—A thin, flat bar of elastic material subjected to bending in its own plane may be unstable in the plane form, and fail by combined lateral displacement and twist. The paper is a mathematical investigation of the subject, based on the ordinary approximate equations for bending. It appears that the instability of such a beam is due to the want of torsional, rather than of flexural, rigidity, so that the same kind of instability may affect beams of other forms. The author attempted to verify one or two of the results given by the theory by experimenting on an engineer's steel

straight-edge, 4 feet long, 4·87 cms. wide, and 0·26 cms. thick. Tested as a cantilever, the mean critical load was 5,900 grammes, while the calculated critical load was 5,750 grammes. Tested as a beam supported at the ends and loaded in the middle, the mean critical load was 24,200 grammes, while the calculated critical load was 24,250 grammes. The chief source of error in the experiments was the want of uniformity in the thickness of the straight-edge, the thickness varying from 0·2550 cms. to 0·2628 cms.; the divergence, between the observed and calculated results, is no greater than might be expected from this irregularity. A. S.

5. *Geissler Pumps.* **G. Guglielmo.** (N. Cimento, 10. pp. 189–198, September, 1899; also R. Accad. dei Lincei, Atti, vol. 7°, 2° Sem. Ser. 5, fasc. 9. November, 1898.)—Practical suggestions as to improvements in construction. A. D.

6. *Demonstrational Apparatus.* **A. Sella.** (N. Cimento, 10. pp. 176–189, September, 1899.)—Two large flasks (30 litres each), each provided with a stopcock, and connected by a narrow tube with a drop of liquid in it, will show the differences of atmospheric pressure when the whole, after being adjusted and stopcocks closed, is inverted and stopcocks opened. In a slab of slate made up of two strips symmetrically arranged with reference to a mesial line, each strip being cut across the laminæ of the slate, and shaped so that the mesial junction runs at an angle to the lines of cleavage of the slate, upon heating one end of the slab the flow of heat will be parallel to the mesial line, but the isothermal lines, as revealed by the change of colour of iodide of mercury from yellow to red at 40°, will not be at right angles to the mesial line, but form with it angles which depend on the relative conductivities of the slate in two directions. A. D.

7. *Hydrometers of Total Immersion.* **A. W. Warrington.** (Phil. Mag. 48. pp. 498–519, December, 1899.)—The hydrometers and method here described are for the purpose of obtaining the densities of liquids or of solids to the greatest possible degree of accuracy. An accuracy of 1 in 10^6 for liquids and 1 in 10^5 for solids is claimed. The glass hydrometer with mercury, or mercury and the solid inside is weighted by platinum rings dropped over the short stem until it almost sinks in the liquid or the water, and the temperature is then slowly raised until the hydrometer neither sinks nor rises. The temperature is then very accurately read. The whole experiments are done in a thermostat. For a description of the apparatus, the precautions to be observed, and the method of experimenting, reference must be made to the paper.

The coefficient of expansion of Jena glass is determined as—

$$V_t = V_o\,[1 + (23{\cdot}714 + 11{\cdot}62t)10^{-9}t].$$

The temperature of maximum density of water is calculated by G. A. Scholl, in a note to the paper, from the results of the author's experiments. He finds $\tau = 3{\cdot}982°$ C. with a total probable error of $\pm 0{\cdot}024°$ C. The specific gravity of quartz was determined as—

$$2{\cdot}650457 \pm 0{\cdot}000013.$$

The paper contains a large number of tables of experimental data. J. B. H.

8. *Microphonic Record of Chronometers.* **A. Berget.** (Comptes Rendus, 129. pp. 712–713, November 6, 1899.)—An account of a method for obtaining

graphical records from chronometers depending on the microphonic transmission of the beats of the escapement. A light microphone with a vertical carbon is simply placed on the chronometer and put in series with a battery of eight cells and a telephone, on the vibrating plate of which is mounted a microphonic transmitter with four carbons. This transmitter is itself in series with a telephonic receiver, of which the membrane executes, in these conditions, and with the help of a current furnished by four dry cells, vibrations of an amplitude sufficient to break at each vibration a contact established between a carbon point and a sheet of platinum fixed to the membrane. The rupture and re-establishment of this contact are utilised to produce on a moving smoked cylinder a record of each beat made by the escapement of the chronometer. Easily read curves are thus obtained. Amongst other advantages of this method is the suppression of personal error in the observation of the chronometer. J. J. S.

9. *Photography of Ripples.* **J. H. Vincent.** (Phil. Mag. 46. pp. 290–296, 1898, and 48. pp. 338–344, October, 1899.)—The papers are continuations of the articles dealt with in Abstract No. 481 (1898). The work is on similar lines. The first contains an account of experiments which illustrate Doppler's principle and certain interference phenomena. The second contains a description of experiments on the refraction of ripples. A shallow portion of liquid corresponds to the optically denser medium. Both papers are illustrated by reproductions of interesting photographs. A. G.

10. *Determination of Mass of Molecules, and Description of a New Calorimeter.* **H. Gerstmann.** (Deutsch. Phys. Gesell., Verh. 1. pp. 194–208, October 20, 1899.)—By determining the heat of solution of a non-electrolytic substance in a liquid when the former is taken (1) in a lump, (2) in a finely powdered condition, and also the heat absorbed on mixing two such solutions of different concentrations, the author proposes, by the application of a rough theory, to determine the number of molecules in a gramme of the substance, and thus the mass of a molecule. His experiments, in which he uses a special modification of Bunsen's calorimeter, have so far given him no other result than that the above two heats of solution differ from each other, as we should expect. He estimates that in the powdered sugar he used there were 150 million particles per gramme. R. E. B.

11. *Size of Molecules.* **G. Jäger.** (Akad. Wiss. Wien., S.ber. 108. pp. 54–57, 1899.)—The sizes of the ions, or electric carriers in an electrolyte, are here calculated from the specific resistance. The resistance is supposed to be entirely due to viscosity—that is, it is simply due to the viscous resistance which the ions meet with in moving through the liquid. The other assumptions made are: (1) That the ions are spheres. (2) That anion and kathion have equal diameters. (3) That the density of the electrolyte is the true density of the material—*i.e.*, the density is equal to the mass of all the molecules divided by their volume, not including the volume of the intermolecular spaces.

From the expression $w = 6\pi\eta v\mathrm{R}$ for the resistance to the motion of a sphere in a viscous fluid, the following expression for the diameter of an ion is deduced :—

$$d = \frac{6v}{e}\sqrt{\frac{\mathrm{M}r\eta}{\rho}}$$

where v is the velocity of the ion corresponding to the potential gradient e, r is the specific resistance of the solution, η is the coefficient of viscosity, M is the molecular weight of the electrolyte, and ρ is the density in the solid (or liquid) state. Applying this to the case of KCl, as with this salt the velocities, and therefore diameters, of the anion and kathion are approximately equal, we find $d=66\times10^{-9}$ cm., while according to the kinetic theory of gases the diameter of the chlorine atom is $d=96\times10^{-9}$ cm. J. B. H.

12. *Conservation of Energy in the Human Body.* **W. O. Atwater** and **E. B. Rosa.** (Phys. Rev. 9. pp. 129–163, September, and 214–251, October, 1899.)—This is an account of an elaborate and careful set of experiments on the income and expenditure of material and of energy in the human body. A calorimetric chamber was constructed, in which a man could live for several days, and was provided with a very complete set of measuring appliances. The chamber was thermally isolated from its surroundings, and a system of electric heaters, and pipes carrying cold brine for cooling arranged so that the internal and external temperatures could (by means of thermocouples) be exactly balanced; hence no heat transfer occurred through the walls, and the entire quantity of heat generated in the chambers was carried off and measured by a current of cold water. The air supply was regulated by means of a combined meter and pump which is described in detail: and the air given out was analysed for carbon dioxide and water vapour. All the food, &c., was carefully analysed, and its thermal value determined by the calorimetric bomb method. The accuracy of the calorimeter was tested (i.) by generating heat in it electrically, and measuring the heat on outflow by the water; (ii.) in order to approach the conditions of experiment more nearly, by burning alcohol in a lamp. The data required (dynamical equivalent of heat, latent heat of steam, &c.) and the sources of error are all duly discussed with the result that the calculated and observed quantities of heat agree to one or two parts per thousand. The same degree of accuracy was obtained in the measurements of carbon and hydrogen taken in and given out in the alcohol experiments.

Experiments on a human subject are then described. The energy spent per day when the subject rested, was about 2,310 cals.; when doing 256 cals. of work it amounted to 3,726 cals., giving an efficiency of 7 per cent.

R. A. L.

13. *Investigations in Capillarity.* **Rayleigh.** (Phil. Mag. 48. pp. 321–337, October, 1899.)—The article is divided into four parts, which are comprised under the headings, (1) the size of drops, (2) the liberation of gas from supersaturated solutions, (3) colliding jets, (4) the tension of contaminated water-surfaces.

Neglecting viscosity, the mass of the drop delivered from the lower end of a vertical tube is given by the equation $Mg/Ta=F(T/g\sigma a)$, where M is the mass of the drop, g the acceleration due to gravity, T the surface tension, a the external radius of the tube (liquid supposed to wet the tube), σ the density of the liquid, and F an arbitrary function. Within certain limits the author experimentally determines the nature of the arbitrary function; hence, within the limits, the surface tension of a liquid can be calculated when the size of a drop and certain other quantities are known. An approximate equation is $Mg=3{\cdot}8\,Ta$.

The author does not come to a decisive opinion with regard to the explanation of the liberation of gases on surfaces in supersaturated solutions. The activity of iron wires was destroyed by heat, and they were sealed in glass tubes containing air. After long periods, on taking out of the tubes, they were found to be inactive, but exposure to the air of the laboratory for a day or two restored activity.

In the section on colliding jets, the author shows that just before two jets coalesce the viscosity of the intervening gas must play an important part. The solubility of the gas assists coalescence—a fact confirmed by experiments.

The fourth section contains a description of experiments carried out with the aid of the trough of Miss Pockels. The conclusion is confirmed that, judged by the drop in surface tension, the effect of contamination by oil comes on suddenly; and curves are drawn which show the relation between the degree of contamination and surface tension. One explanation of the cause of the fall in surface tension leads to the conclusion that the first fall in the surface tension corresponds to a complete layer one molecule thick, and that the diameter of a molecule of oil is about 1×10^{-7} cm. Another less probable explanation gives a different result. A. G.

14. *Efflux of Permanent Gases.* **R. Emden.** (Wied. Ann. 69. 2. pp. 426–458, October, 1899.)—The present paper contains the mathematical theory of the efflux of gas under pressure. The author starts from the position that, if the efflux is steady, equal masses and equal quantities of energy must pass the space between two cross-sections of the tube in each unit of time, and he arrives at some important generalisations. The velocity with which the gas passes the orifice can never become greater than the velocity of sound at that point. This maximum velocity holds good when the critical ratio of pressures obtains between the internal and the external pressure. This singular pressure at which a gas-jet emerging into the atmosphere begins to pass the orifice with the velocity of sound, corresponds to the velocity of efflux at which stationary sound waves are formed in the jet. After the critical ratio of pressures is passed, the jet issues at all points with the velocity of sound, and at every point the pressure is that of the atmosphere. The author points out that in this manner sound waves of very small wave-length and very high frequency may be produced, possessing greater energy than any yet produced. E. E. F.

15. *Theory of Diffusion.* **E. Bose.** (Zeitschr. Phys. Chem. 29. pp. 658–660, September, 1899.)—The paper gives the theory of the diffusion of a partially ionised electrolyte which breaks up into two ions.

Let c_u equal the concentration of the unionised part; c_d the concentration of the ionised part; and c the combined concentration. (Thus $c = c_u + c_d$.) The relationship between c_u and c_d in certain cases and between certain limits is given by the equation $k.c_u = c_d^2$.

In the case of a cylinder of length l, and cross-section q, one end of which is at a concentration c_1, the other c_2, the quantity S transmitted in time z when a steady state has been attained is given by the formula,

$$S = RT.\frac{q}{l}.z.\left[W(c_2 - c_1) + 2\left(\frac{UV}{U+V} - W\right)\left(\sqrt{\frac{k^2}{4} + kc_2} - \sqrt{\frac{k^2}{4} + kc_1}\right)\right],$$

where R and T are the quantities which occur in the equation $pv = RT$; W is the velocity produced by unit force acting on the gramme-molecule of the unionised electrolyte; and U and V are corresponding velocities for the ions. Attention should be paid to the hypothesis that $kc_u = c_d^2$. The formula indicates that strictly there is not a constant of diffusion. The author suggests that the formula should be tested by experiments with an electrolyte like acetic acid. A. G.

16. *Densities of Saturated Vapours.* **R. von Hirsch.** (Wied. Ann. 69. 2. pp. 456–478, October, 1899.)—The author investigated the critical densities of toluol, xylol, propionic acid, and butyric acid by Young's method of enclosing two different quantities of the substance in a sealed glass tube and observing the disappearance of the meniscus in the two cases. He comes to the conclusion that in the temperature-density curve the critical temperature line is not a tangent to the curve of densities, but that the curve meets the line in two points close together. Above the critical temperature the density of the substance is represented by an ordinate whose position can be altered between certain limits by the filling of the tube. When the critical temperature is exceeded, there is always an abrupt change of density. Such a change of density could not take place if solid and liquid had the same density, since the volume is constant and the weight unalterable.
E. E. F.

17. *Explosions in Air.* **W. Wolff.** (Wied. Ann. 69. 2. pp. 329–371, October, 1899.)—The energy of explosion of a body is determined by its weight and its heat of explosion. It is spent in destruction at the seat of explosion, in earth tremors, in the motion of projected matter, and in the vibration and motion of masses of air. If the latter impinge upon a body, the quantity of energy absorbed by it depends upon its properties. If the body is absolutely hard and firm, it reflects all the incident energy. The author has, on behalf of the Prussian Artillery Testing Commission, made some experiments at Cummersdorp to determine the type of motion produced in the air by an explosion. He finds that the type is essentially that of the sound wave, though the velocity of propagation increases with the violence of the explosion. The main difference lies in the fact that the explosion produces a finite condensation, whereas the condensation in a sound wave is infinitesimal. As the wave passes away from the origin its velocity of propagation decreases, so that the wave-front becomes steeper. There is no bodily translation of air to distances over some 25 m. But the translation within that radius leads to a subsequent wave of rarefaction, which is propagated with nearly the same velocity as the primary wave, and accounts for the indirect effects of the explosion, and for the projection of bodies towards the origin. E. E. F.

18. *Mass of a Cubic Decimetre of Water.* **C. Fabry, J. M. de Lépinay,** and **A. Pérot.** (Comptes Rendus, 129. pp. 709–712, November 6, 1899.)—The authors have previously described the method adopted to measure in wavelengths the dimensions of a parallelopiped of quartz, of edge about 4 cm. Their object was to determine the volume of this solid in view of a new determination of the mass of a cubic decimetre of water. The faces of the solid being neither perfectly plane nor parallel two and two, it is necessary to investigate how the thickness varies from one point to another in each pair of faces. The optical methods adopted to obtain these differential measurements are described in the present paper, and from these measurements the trace of the curves of equal thickness for the three pairs of faces is obtained. Having these curves as well as the absolute thickness at one point, the mean thickness corresponding to the pair of faces considered is obtained by means of the planimeter. The volume of the cube of quartz deduced from the measurements is 61·75136 cc. On the other hand the mass of water at 4° displaced by this solid was exactly known from determinations of its mass and its density. This mass of water is 61·75004 grs. Hence the mass of 1000 cc. at 4° is 999·9786 grs., or 1 kilogr. — 21·4 milligrs. This result is considered exact

within a few milligrammes. It agrees with the number which Chappuis has obtained as a provisional result of measurements made on cubes of glass by Michelson's method, viz., 1 kilogr. — 24 milligrs. J. J. S.

19. *Air-Resistance to Projectiles.* **R. Emden.** (Wied. Ann. 69. 2. pp. 454–455, October, 1899.)—The additional function of the velocity which makes up the total resistance of air encountered by a projectile suddenly increases between the velocities of 300 to 400 m. per second, but is approximately constant above and below that value. The author offers the following explanation: The projectile has to perform work in overcoming the air resistance. This work increases as soon as the velocity has increased to such an extent that Mach's conical head-wave is formed. This head-wave is formed as soon as the projectile attains the velocity of sound. But every sound wave contains a certain amount of energy, and this energy must be derived from the kinetic energy of the missile. The expenditure of energy increases until the head-wave has attained its maximum intensity. It must always be newly generated, but the additional resistance is constant after the maximum intensity is reached. This would explain what is found to occur, but the existence of a maximum intensity of the head-wave remains to be demonstrated.

E. E. F.

20. *Production of Waves in an Elastic Solid.* **Kelvin.** (Phil. Mag. 48. pp. 388–398, October, 1899.)—This is the concluding portion of the memoir (see 1898, Abstracts Nos. 1120 and 1631). The cavity in the elastic solid is supposed to have a rigid massless spherical lining called the sheath. A mass m is mounted on massless springs within the sheath. The author investigates what must be the force in simple proportion to the velocity of m which will keep the sheath vibrating in simple harmonic motion $h \sin \omega t$, and therefore will do the work of sending out the two sets of waves treated in the former numbers. The velocities of the equivoluminal and irrotational waves are u and v respectively; q is the radius of the sheath. Two cases are considered: (1) $q\omega$ is very large compared with the greater of u and v; (2) $q\omega$ is very small compared with the smaller of u and v. Then, c denoting the stiffness of the system of springs, the results are considered according as c is very small or infinite. Then he considers the case of v being infinite, which is important in the Dynamical Theory of light. Lastly, the example suggested in Phil. Mag., March, 1899—a large mass of granite with a spherical hollow of 10 centimetres diameter acted on by an internal simple harmonic vibrator of 1006¼ $\left(1000\sqrt{\frac{10}{\pi^2}}\right)$ periods per second, and again when it has 1·0065 periods per second. S. H. B.

21. *General Equation for Free Energy and Physico-Chemical Equilibrium.* **G. N. Lewis.** (Amer. Acad., Proc. 35. pp. 3–38, July, 1899.)—In Part I. of this paper the author obtains a perfectly general expression, equation (6), in his work, for the change of free energy in any isothermal change, chemical or physical, in any system, whether homogeneous or heterogeneous. He then applies it to the case of gases and dilute solutions, and deduces a general equation for equilibrium in any system, leading with some extension to the mass law of Guldberg and Waage, and also that of Henry.

In Part II., treating of monomolecular systems, he shows that an equation nearly identical with that of van der Waals can be deduced from his general equations by the aid of two empirical observations, namely, the constancy of the specific heat of gases at constant temperature, and the proportionality between the cooling effect and the fall in pressure in the free expansion of gases. Instead of van der Waals' constant b, he obtains an undefined function of the volume. For van der Waals' constant a in $\frac{a}{v^2}$ he would also use a function of the volume. He proposes a more general equation recognising the variability of specific heat with volume. A formula is obtained for equilibrium between a liquid and its vapour. The vapour pressure curve is also discussed.

In Part III., the application of the general equation to solutions leads to expressions for osmotic pressure and osmotic work in concentrated solutions, and an equation is given for the distribution of a solute between two solvents.

In Part IV. the influence of the nature of the solvent on general homogeneous equilibrium is discussed.

Part V. deals with the application of the general equation to electrochemistry. S. H. B.

22. *Formation of Clouds with Ozone.* **J. S. Townsend.** (Cambridge Phil. Soc., Proc. 10. pp. 52–58, 1899.)—When ozone is bubbled through a solution of potassium iodide, a cloud forms over the solution. In explanation, Meissner has suggested that the silent discharge produces both ozone and antozone, and that the antozone, after the removal of the ozone, condenses water. The author prepared ozone from pure oxygen in a Babo apparatus, consisting of two sets of fine glass tubes containing platinum wires, enclosed in a large glass tube. A large flask is partly filled with water. Gases can be introduced through two tubes, not dipping into the water; the one brings dried ozonised oxygen, the other oxygen which has passed over—not through—a solution of potassium iodide. No cloud is formed over the water. But when some iodine is dissolved in the iodide, then a cloud appears where the two gas streams meet. The cloud cannot be due to spraying, since the tubes do not dip into the water. The clouds seem to be produced by the action of ozone on the iodine vapour which the stream of oxygen had carried with it, and they consist mainly of water vapour. A solution of sulphur dioxide gives similar results. Bubbling the oxygen through the iodide or through a solution of metabisulphite of sodium also gives clouds, which become denser when the solution is gently heated; sodium sulphite gives no cloud. The ozone seems to oxidise the iodine or sulphur dioxide, yielding, in the presence of water, iodic or sulphuric acid. The cloud disappears when the gas is dried by passing through sulphuric acid, and reappears in the presence of moisture. There remain behind in the gas, says the author, very small particles which consist of the non-volatile body which prevented the drops forming the cloud from evaporating under the action of surface tension. In order to ascertain whether or not the centres round which the drops form are electrically charged, the gases which were capable of producing a cloud were passed through an aluminium cylinder whose insulated axis was connected with a quadrant electrometer. No change could be detected. H. B.

23. *Newtonian Constant.* **G. K. Burgess.** (Comptes Rendus, 129. pp. 407–409, August 21, 1899.)—This is a description of a piece of apparatus used in Lippmann's laboratory for the determination of the gravitational constant. W. G. R.

24. *Gravity in Piedmont.* **C. Aimonetti.** (Accad. Sci. Torino, Mem. 34. pp. 550–561, 1899.)—The chief results are given in the following table :—

Stations.	Gravity observed.	Correction for height.	Correction for Mass underneath.	Gravity reduced to sea-level (G'_0)	Gravity theoretical (G_0)	Anomaly of gravity $(G'_0—G_0)$
Fossano	9·80430	+116	−31	9·80515	9·80556	− 41
Cuneo	487	163	52	548	541	+ 7
Alba	465	52	18	499	569	− 70
Alessandria..	468	25	8	485	589	−104
Voghera	470	30	9	491	596	−105
Asti	471	38	13	496	587	− 91
Chivasso	546	55	19	582	614	− 32
Crea............	417	186	44	509	605	− 96
Vercelli	564	40	12	592	626	− 34
Novara	611	49	15	645	637	+ 8
Turin	570	72	24	618	603	+ 15

Considering a line from Turin to Milan, it is seen that there is an excess of mass at Turin, a deficiency at Chivasso and Vercelli, and again a slight excess at Novara. Along a parallel line, from Cuneo to Voghera, after a slight excess at Cuneo, there is a deficiency whose value increases gradually until Voghera is reached, where the deficiencies are greater than at Chivasso and Vercelli.

A. G.

25. *Humidity Variations on the Coast of the Adriatic.* **E. Mazelle.** (Akad. Wiss. Wien., S.ber. 108. pp. 281–322, 1899.)—Hourly observations were taken during the ten years 1886–1895, all with the same thermo-hydrograph of Hasler and Escher, at the Navy Hydrographic station of Pola. The hut has since been arranged in modern fashion, so that comparative data will be available some years hence. The maximum relative humidity was observed at 4·8 h. a.m. in January, at 6, 5·9, 5·4 h. in the following months, at 4·9, 4·6, 4·7, 4·4, 4·4 h. during the summer up to September, and at 5·9, 6·8, 5·2 h. a.m. in the last months of the year. Thus the maximum precedes the sunrise in winter and changes little as to the hour during the summer months. The minimum follows at 1·7 h. p.m. in January, and about 0·5 h. p.m. in summer. When serene days (uninterrupted sunshine record) and overcast days are distinguished, the amplitudes of the relative humidity are found to be greater on serene days and in summer generally (maximum in July), than on overcast days and in winter (minimum in November). The extremes are delayed in winter and spring, and advance as the season passes from summer into winter. Waves of relative humidity, a continued general increase followed by a decrease, have an average length of 8·16 days; they are a little shorter in summer and longer in winter. As a rule the ascending branch is longer than the period of decrease. The paper is essentially tabular; curves are not given.

H. B.

26. *Kites for Meteorological Research.* **C. F. Marvin.** (Frank. Instit., Journ. 148. pp. 241–259, October, 1899.)—The U.S. Weather Bureau had seventeen kite stations in 1898, of which, owing to limited funds, only three were in operation at the end of the year. The work is under the superintendence of the author. The standard kite is of the Hargrave type with three frames of spruce strips—straight, not curved—braced and strengthened by steel wire ties. The two bands, the one of white cambric, the other of black percaline, are 2 feet wide and 28 inches apart. The bridle cord is attached at a single point, well forward; the safety line is also a cord, not an elastic spring or cord as often proposed. The steel wire of the line 0·028 inch in diameter, has a tensile strength of over 200 lbs. and is applied in lengths of 7,000 feet The hand-reel on which it is coiled (at Washington a steam windlass) must be exceedingly strong. The inclination of the line is measured with the help of aluminium arms and a graduated circle; the angular elevation by the Marvin nephoscope, a mirror with an adjustable sighting staff, through which and through the centre of the mirror a weighted thread passes. In the line inclination, a correction is made for the sag, not for the lateral wind pressure on the wire. The Marvin meteorograph is fixed within the box-frame of the kite, and not suspended below the kite, and consists of a drum, revolving once in twelve (or in one) hours, and a tube parallel to it through which the wind blows. The tube contains the hair hygrometer and the thermometer, a pair of Bourdon tubes completely filled with alcohol. The lag of the thermograph is 1° F. when the temperature changes at the rate of 1·5° per minute, which corresponds to the ordinary rise or fall of the kite, 500 feet per minute. The aneroid barometer has a steel chamber. The wind-velocity is measured by anemometers. Four pens rest on the drum. H. B.

27. *Laziale Earthquake, July* 19, 1899. **C. Bassani.** (Rivista Sci. Industriale, 31. pp. 169–171, August 10, 1899.)—According to the author's calculations the seismic centre was under Monte Cavo at a depth of 16·12 kilometres; and the total energy of the shock was $1\cdot5\times10^{\text{[illegible]}}$ kilogram-metres.

A. G.

28. *Seismometric Observations in Göttingen.* **E. Wiechert.** (Gesell. Wiss. Göttingen, Nachr. Math. Phys. Klasse, 2. pp. 195–208, 1899.)—The observations are taken by means of a seismograph consisting of a horizontal pendulum, one end of which presses against a point, whilst the other is supported by a thread. The pendulum is of a conical shape; it is almost surrounded by a fixed cone; the intervening space is only a few millimetres across, and the air-damping is considerable. The whole is surrounded by a cover provided with a glass window. The free extremity of the pendulum is provided with a mirror, and, by suitable means, any motions are registered photographically on a rotating cylinder. The yearly cost of the photographic paper, gas, &c., for one pendulum is about 170 marks. Two, which would enable the components of the earth-disturbances in two directions to be determined (the same lamp would do for the two), would cost about 280 marks yearly. Apart from seismic actions, the pendulum is subject to two disturbances: shaking arising from the action of wind upon the building, and movements of the support due to changes of temperature. Experience teaches how to distinguish between these disturbances and the seismic actions. The instrument is proving a serviceable one, and some interesting reproductions of the graphs show that it has recorded the earth-movements due to earthquakes with centres at great distances. A. G.

29. *The Solar Corona.* **T. Bredikhine.** (Acad. Sci. St. Pétersbourg, Bull. 9. pp. 179–207, 1898.)—Using photographs of the sun's corona, the author graphically determines the various hyperbolic paths along which the coronal

matter appears to move, by placing hyperbolic curves with their foci at the sun's centre, and trying consecutive curves until one is found to fit a particular path (the effect of perspective, which is readily noticeable in some cases, being neglected). From the observed velocity of solar protuberances, the author is led to form an estimate of the probable initial velocities of the coronal matter; these may range from 200 to 600 kilometres per sec., and in some cases may reach even 900 kilometres per sec. The author points out the close analogy between the tails of comets and the sun's corona, and, making the assumption that each particle describes its path under the action of two forces—a gravitational attracting force due to the sun's mass, and an unknown repelling force—calculates the value of this latter from the graphically determined paths and the assumed initial velocities. The result of this investigation is to show that the force of repulsion either very nearly balances that of attraction, or else differs from it by only a small amount. In general, the coronal matter which is being ejected from a given point on the sun's surface will, at a given instant, have the form of a spiral consisting of one or more turns, according as the period of eruption does not or does exceed the time of the sun's revolution. The various portions of this spiral move outwards almost exactly along their radii vectores. The author then throws out several suggestions regarding the causes of these eruptions: it is possible that when portions of the sun's substance originally in its interior are quickly brought to the surface, the sudden release from an enormous pressure causes a violent scattering of the particles; again, under the influence of the sun's atmosphere, the ionised particles may conceivably be deprived of the electric charges of one sign, those of the opposite sign only remaining; the force of repulsion might then be explained as due to the electric potential of the sun. In conclusion, the author refers to the work of Bigelow and Schaeberle on this subject. A. H.

REFERENCES.

30. *Elastic Deformations of a Reversion Pendulum.* **E. Almansi.** (N. Cimento, 10. pp. 85–111, August, 1899.)—A further mathematical investigation of the internal forces normal to the movable axis. (See 1899, Abstract No. 1460.) E. E. F.

31. *Dynamical Theory of Capillarity.* **G. Bakker.** (Journ. de Physique, 8. pp. 545–552, October, 1899.)—A mathematical paper dealing with the bearing of cohesion, molecular pressure, internal heat of evaporation, &c., on surface tension. (See also 1899, Abstract No. 1320.) A. G.

32. *Units of Measurement.* **W. Moon.** (Elect. Rev. 45. pp. 736–737, Nov. 3, and pp. 861–862, Nov. 24, 1899.)

33. *Reflection and Refraction of Elastic Waves.* **C. G. Knott.** (Phil. Mag. 48. pp. 567–569, December, 1899.)—Correction to C. G. Knott's paper (see 1899, Abstract No. 1633), pointed out by T. Gray.

34. *Physical Life of the Earth.* **A. Klossovsky.** (Revue Scientif. 12. pp. 289–295, September 2nd; pp. 364–369, September 16th; pp. 424–429, September 30th, 1899.)—This is an interesting review of the various physical phenomena, atmospheric and terrestrial, observed from the earth's surface, and their possible explanation by the application of electrical theories. The paper is too discursive to abstract in detail. C. P. B.

LIGHT.

35. *Refractive Index of Liquids, II.* **C. Bender.** (Wied. Ann. 69. 3. pp. 676–679, November, 1899.)—This part of the author's work deals with the refractive index of water for the three lines H*α*, H*β*, and H*γ*, between the temperatures 40° and 70°. For H*α* the refractivity of pure water is represented by the formula $1·3319977-0·00002372t-0·0000011362t^2$. For H*β* the first term is 1·3377690, and for H*γ* it is 1·3409668, the temperature coefficients being the same for all the three lines. (See 1899, Abstract No. 1471.) E. E. F.

36. *Double Refraction in Liquids.* **B. V. Hill.** (Phil. Mag. 48. pp. 485–498, December, 1899.)—The double refraction introduced in solutions of colloids by stirring is here studied. The solution was placed in a bath which contained also two parallel cylinders, one of which was rotated. (See Phil. Mag. 44. p. 499.) The light passed through the solution between the cylinders. A half-shadow apparatus was used to measure the rotations. Homogeneous light obtained by passing sunlight through absorbing solutions was used. Solutions of the colloids gelatine and gum-arabic and the crystalloids hyposulphite of soda and cane-sugar were studied. With the crystalloids no double refraction is observed, but with the colloids the double refraction varies with the speed of rotation of the cylinder and also with the concentration. With a solution of gum-arabic the double refraction is proportional to the speed, but not proportional to the concentration; but in this respect the effect depends very much on how the solutions have been treated and made. With solutions of gelatine, for small velocities the double refraction increases with the speed, though not in proportion to it. This increase continues up to a certain point, where an elastic limit seems to be reached. Beyond this point the amount of double refraction decreases and finally changes sign as the speed is increased. With very dilute solutions (1 gramme per litre) this breaking down takes place at so small a speed that it cannot be observed, and the decrease of the double refraction with the speed is very slow. In solutions of gelatine under the same conditions the double refraction is proportional to the concentration. A number of tables and curves are given in the paper.

The author concludes that these solutions of colloids are not true solutions in the proper sense of the term, since their behaviour is much more like that of an elastic solid, being able to sustain strains if not distorted too much. Also, if diluted to half the concentration, the double refraction is indefinite and is not halved until the solution is again boiled and cooled. There must therefore in these solutions be a structure similar to that of jellies. J. B. H.

37. *Strain in Glass Drops.* **K. Mack.** (Wied. Ann. 69. 4. pp. 801–803, December, 1899.)—Strained glass plates show striking colours in polarised light. Glass "tears" appear black owing to total reflection. But they can be made to show their colours by immersing them in a glass trough containing a liquid of the same refractive index, such as cedar oil, or a mixture of carbon bisulphide and ethyl ether, or a solution of chloral hydrate in glycerine. The colours resemble those of peacock feathers or butterfly wings. They make a striking lecture experiment. E. E. F.

38. *Focussing a Collimator.* **G. Lippmann.** (Comptes Rendus, 129. pp. 569–570, October 16, 1899.)—The slit is viewed through an auxiliary telescope, and a bi-plate is interposed between the telescope and the collimator. The bi-plate consists of two plates of glass with their edges adjoining

and parallel to the slit, and their surfaces at right angles to each other and at 45° to the path of the beam. Two images of the slit are then seen in the telescope. The collimator is focussed until the two images become one. When that happens it is focussed upon infinity as required. E. E. F.

39. *Correction for Thickness of Lens and Mirror in Magnetometers.* **S. Hlasek.** (Acad. Sci. St. Pétersbourg, Bull. 9. pp. 83–90, 1898.)—It has recently become common practice to close the opening through which the light passes into the chamber containing the suspended magnet by a lens instead of a plane piece of glass, as this arrangement requires only an eyepiece for reading off the deflection, and is thus cheaper. The formula which is generally used for calculating the corrected distance of the scale is—

$$e_o = e\left\{1 - \frac{d(e-d)}{ef}\right\}$$

where e_o and e stand for the corrected and measured distances respectively of the scale from the mirror, d for the distance of the lens from the mirror, and f for the focal length of the lens. The author points out that this formula may lead to appreciable errors, since it takes no account of the thickness of the lens, and since neither e nor d are sufficiently well defined. He then deduces the following more accurate formula—

$$e_o = e\left\{1 - g\frac{e-g}{ef} + \left(\tfrac{2}{3}\delta - \tfrac{\Delta}{3}\right)\cdot\frac{f-g}{ef}\right\},$$

in which $g = d + \frac{2}{3}\delta + \frac{\Delta}{3}$, d being here the distance of the front plane of the mirror from the lens surface facing it, δ the thickness of the mirror, Δ that of the lens, and e the distance of the scale from the front plane of the mirror.

A. H.

40. *Mechanical Working of Optical Surfaces.* **P. Gautier.** (Journ. de Physique, 8. pp. 477–483, September, 1899.)—The truth of a plane surface is best tested by means of a round luminous patch reflected at a large angle of incidence. When in focus, the patch, observed through a telescope, should be round and surrounded by symmetrical fringes. If the surface is slightly concave, the image will be flattened out laterally on pulling out the eyepiece; if convex, the image will be drawn out vertically. An elevation of only 0·0001 mm. is thus discoverable. In order to avoid bending, the glass must be so thick that a mirror 2 m. in diameter would weigh 3,000 kilogrammes. The working machine must be correspondingly rigid. The machine used for the 2 m. mirror is described. The working occupied three months. The last polish was done in the dry way with paper attached to the grinding surface and lightly rubbed with the finest Tripoli powder. During this operation it was found necessary to keep a distance of 0·03 mm. between the polishing surface and the mirror. After every two minutes' polishing the machine had to be stopped for half an hour to avoid heating. Eventually it was found necessary to give the grinding surface a curvature of 0·005 mm. for the 2 m. The mechanical correction lasted eight months. E. E. F.

41. *New Spectrophotometer.* **D. B. Brace.** (Phil. Mag. 48. pp. 420–430, November, 1899.)—An ordinary spectrometer by the addition of an extra collimator and with a particular prism on the goniometer table is here converted into a spectrophotometer of the most sensitive type. This type is one having no line of separation between the fields to be compared, as realised in the Lummer-Brodhun ordinary photometer. The prism is a composite one, composed of two equal prisms whose angles are 30°, 60°, and 90°, cemented

together so as to make an equilateral triangular prism. One of the two faces cemented together has a strip silvered along its whole length.

Suppose the prism to be mounted on the spectrometer table, and the two collimators to be placed symmetrically to the cemented faces, and in such positions that the two beams from the collimators enter the composite face of the equilateral prism from opposite sides at the angle of minimum deviation. The two beams, or portions of the beams when they emerge from the prism, the one after direct transmission through the cemented faces, the other after reflection in the silvered part of the cemented faces, emerge as spectra, exactly coinciding the one with the other. The instrument is adjusted so that the sodium line of each spectrum coincides with the cross wires in the telescope; any other line in the one spectrum then coincides with the same line in the other. If the eyepiece of the telescope be now removed and a small vertical slit be inserted in the focal plane, the eye, by focussing on the prism through the slit, will see the field illuminated by monochromatic light, and with a band across it which is brighter or less bright than the rest of the field. By adjusting the width of one of the collimator slits the band will disappear, and the two spectra are then of equal intensity for that particular wave-length. By this means any two sources of light may be compared throughout the whole spectrum.

The author describes a convenient method of standardising the slits.

J. B. H.

42. *Spectrophotometry of Electric Light.* **F. Gaud.** (Comptes Rendus, 129. pp. 759–760, November 18, 1899.)—Incandescent and arc lights were compared with sunlight. Each of the lights was decomposed by glass screens of homogeneous colours, and the intensity of the transmitted beams was estimated by Foucault's or Bunsen's photometric apparatus. The light transmitted by the screen was observed by means of a grating, and the angles of deviation measured. Thus the wave-length of the radiation from each screen was found very exactly. Then the sources to be compared were arranged on the photometer, furnished each with a yellow screen, so as to obtain equality of illumination for the D ray. On substituting for the yellow screen the series of coloured screens it was necessary each time, in order to get equality of illumination, to modify the distance of one of the sources, which instead of L became L_1, L_2 . . . The numbers $\left(\frac{L_1}{L}\right)^2$, $\left(\frac{L_2}{L}\right)^2$, . . . measure the photometric ratio of the two lights for each colour considered. Taking these numbers as ordinates with the wave-lengths of the corresponding colours as abscissæ a curve is obtained which gives the exact measure of the ratios for the principal rays of the spectrum. The following is a table of these ratios :—

Wave-length.	Incandescent Light. / Sun.	Arc Light. / Sun.
800 μ	11·86	1·67
Ray A	4·88	1·37
„ B	2·68	1·28
„ C	1·25	0·97
„ D	1·00	1·00
„ E	0·88	0·77
„ F	0·17	0·56
„ G	0·10	0·83
„ H	0·05	1·21

J. J. S.

43. *Photometry of Acetylene.* **L. W. Hartman.** (Phys. Rev. 9. pp. 176–188, September, 1899.)—An account is given of the photometric study of mixtures of acetylene and hydrogen burned in air. The results are exhibited by means of curves. From these it appears that the acetylene-hydrogen flame is richer in the short wave-lengths than the flame burning acetylene alone used as a secondary standard. Moreover, the colour properties of the flame appear to be independent of the amount of hydrogen in the mixture. Upon going to the limit this statement would not hold true. Lava tip and brass tip burners were used. In the case of the brass tip it is shown by curves giving the relation between percentage of acetylene and candle-power, that the candle-power reaches a maximum and then falls away with increasing percentage of acetylene. This is due to the incomplete combustion of the gas after a given percentage of acetylene in the mixture has been reached. In the case of the lava tip, the flame with low percentages of acetylene appears very like the flame of burning hydrogen: at first it slowly increases in candle-power with increasing percentage of acetylene, and does not reach the stage of incomplete combustion. J. J. S.

44. *Photometry of Arc Lamps.* **F. Laporte.** (Soc. Int. Elect., Bull. 16. pp. 288–302, June, 1899.)—The author describes a method of measuring the total mission of an arc lamp by reflecting its light into a photometer by a mirror capable of travelling in a circle round the lamp, the rotation taking place about the axis of the photometer. In practice two such mirrors are used. E. E. F.

45. *Photometry of the Electric Arc.* **E. W. L. Richter.** (Elekt. Runds. 16. pp. 288–289, August, 1899.)—The electric arc is divided into three parts: (*a*) a green-tinged aureole, (*b*) a darker mantle of flame, (*c*) a bright blue-violet nucleus. The relative actinic intensities of these three parts depend very much upon the kind of carbons used. Experiments are described in which a Nicol's prism photometer is employed for comparing the apparent relative intensities, using in some cases carbons with a known percentage of a salt, such as sodic chloride. In one case mentioned, using solid carbons 18 mm. diameter, with an arc-length of 6 mm., 15 amperes, and 56 volts, the ratios are—

$$b : a : c = 1 : 2{\cdot}28 : 3{\cdot}32.$$

The brightness of the sodium line is greater in *a* and least in *b*, and is a function of the temperature and of the quantity of sodium vapour. R. A.

46. *Maximum of Radiation.* **F. W. Very.** (Astro-Phys. Journ. 10. pp. 208–210, October, 1899.)—The author discusses some courses of observed deviations from Paschen's law,

$$\lambda_{max} \times T = 2891.$$

"Two causes conspire to produce these differences. (1) The imperfect absorption of long waves by the simply blackened bolometer makes the wave-length of the apparent maximum too small, and this to a greater degree as the temperature is lower and the maximum in the spectrum nearer to these long waves whose absorption by the blackening substance becomes less and less as the wave-length increases. (2) The temperatures of thick radiating plates are estimated too high, on account of neglecting the sub-surface temperature-gradient which is larger and increases the assigned maximum more, the higher the temperature. The first of these causes of error is eliminated in

Paschen's recent work by the use of what may be called a repeating bolometer, in which the strip has repeated opportunities for absorbing the reflected remnant of radiation; and the second has been obviated by the use of radiant cavities and extremely thin radiant strips, reducing the sub-surface gradient to a minimum." E. E. F.

47. *Remnant Rays of Fluorspar.* **H. Rubens.** (Wied. Ann. 69. 3. pp. 576–588, November, 1899.)—When the radiation of any source of heat is repeatedly reflected from fluorspar surfaces, the emergent rays all belong to a certain infra-red region from which fluorspar exhibits metallic reflection. The author calls these rays remnant rays (*Reststrahlen*). Their wave-length varies between 24·4 and 28·7 μ. The energy curve is unsymmetrical, being steeper on the more refrangible side. A new examination by means of an improved thermo-couple reveals the existence of a second maximum in the energy-curve, situated at $\lambda = 31·6$. It is the clearer the greater the number of reflections. E. E. F.

48. *Propagation of Luminous Vibrations through Matter.* **G. Sagnac.** (Comptes Rendus, 129. pp. 756–758, November 13, 1899.)—The author considers the luminous vibrations in the interior of a body as being propagated by the intervention of a medium identical with the ether of a vacuum, and not differing from it in density or elasticity. Instead of considering mechanical reactions between the ether and matter, account is taken of the *discontinuity of matter* by a mechanism chiefly kinematic, as follows:—

Each particle or atom of the material medium sends back in all directions a definite proportion of the vibrations which fall upon it. This reflection-diffraction of the luminous vibrations by a material particle may be compared to the reflection-diffraction of Hertz's electric vibrations by a small conducting body *in vacuo* of very small dimensions compared with the wave-lengths of the incident electric vibrations. Consider the fundamental case of a series of plane luminous waves of single period arriving in a vacuum parallel to the plane surface P of a very transparent isotropic medium. Each layer of particles of the medium separates the vibrations which meet it into transmitted and reflected vibrations. The same subdivision goes on by transmission and reflection at the different layers of particles. There is thus produced a number (theoretically infinite) of systems of elementary vibrations having undergone transmissions and reflections more or less numerous. All the elementary vibrations which have undergone an even number of reflections at the particles are propagated towards the interior of the material medium. At the same plane S, parallel to the surface P of the medium, these vibrations arrive with different phases on account of the different paths that they have traversed *in vacuo* from one reflecting particle to another. The resultant of these elementary vibrations of even order defines at each free point of the plane S the periodic vibration transmitted to the interior of the medium. In the same way the elementary vibrations which have undergone an odd number of reflections come back to traverse the surface P of the medium; their resultant defines, at each free point of P, the vibration reflected at the surface of the medium.

When the plane S withdraws into the medium to a distance from the surface P superior to a certain value E, the vibrations of uneven order which traverse the plane S in the direction of P are sent back by the layers of particles comprised between S and P sensibly as if the distance e from S to P was infinite. After this, the same increase Δe of the thickness e of matter between S and P produces always the same increase Δr of the retardation r of the refracted vibration. The retardation r is considered as the mean, determined by the rule of Fresnel, between the different retardations δ that the different elementary vibrations of even order have experienced during their course back and forward *in vacuo* between the reflecting particles. The elementary retardations δ increase by successive degrees comparable to double the mean distance of the particles; therefore, in general, by degrees extremely small compared with a wave-length. All these retardations δ surpass the thickness e of the medium traversed: the ratio, $\frac{\Delta r}{\Delta e}$, henceforth constant, is above unity; it is the *index of refraction*, n, of the medium. According to this mechanism, the velocity of propagation of the transmitted vibration takes a constant value V equal to V_0/n (the velocity of a plane wave *in vacuo* being V_0), only beyond the optical layer of passage determined by the thickness E of the medium supposed perfectly homogeneous. J. J. S.

49. *Fault in Lippmann's Colour Photography.* **O. Wiener.** (Wied. Ann. 69. 2. pp. 488–530, October, 1899.)—The author points out and explains the faults in the pictures produced by the peculiar interference of the rays reflected from the gelatine surface with the rays proceeding from within the gelatine itself. There is always a difference of phase between the surface wave and the wave reflected from Lippmann's first elementary stratum, and this difference of phase displaces the spectrum colours towards the red, and produces wrong colouring. The obvious remedy is to eliminate the surface reflection altogether. This can be done by inserting the finished plate in a bath of benzol, which has about the same refractivity as gelatine, and therefore eliminates the reflection at the surface of the latter. A less circumstantial remedy consists in producing a large difference of path between the surface wave and the first elementary wave, by coating the gelatine with a layer of collodion. If this layer is made of such a thickness as to make the phases of the two waves coincident, very brilliant and true effects are obtained; but that can only happen by a fortunate accident, as the thickness required differs with the colour. About 9 to 13 elementary layers contribute to the reflection of the colours, and each of them is probably about 1·4 $\mu\mu$ thick. The phase displacement of these layers is not zero, as assumed by Lippmann, but may under certain conditions attain a quarter-wave-length. E. E. F.

50. *Electrophotography.* **L. Fomm.** (Wied. Ann. 69. 2. pp. 479–482, October, 1899.)—A study of Lichtenberg figures has led the author to devise a plan for photographing sections of different kinds of wood by simple contact. The sections must be thin and smooth. They are covered on one side with tinfoil, and on the other with a sheet of bromide paper, with the gelatine in contact with the wood. A negatively charged metallic point is mounted at a distance of 5 cm. from the paper surface. An influence machine produces a good impression in about half a minute, showing clearly the cambium rings and medullary rays of the wood. What happens is that the paper is negatively charged, and the narrow layer of air between it and the wood is filled with photographically active glow-light, which varies in intensity according to the nature of the woody substance. The electrophotograph thus obtained is not necessarily similar to an ordinary photograph, since the light and shade does not depend upon the optical character, but upon the physical or chemical structure of the surface. Thus the medullary rays of oak come

out bright, those of beech dark, though optically they are both bright. The reason is that the medullary rays of oak contain much starch, those of beech but little. E. E. F.

51. *Action of Coloured Light on Silkworms.* **C. Flammarion.** (Comptes Rendus, 129. pp. 398–401, August 14, 1899.)—The maximum production of silk takes place in white light, and the next in the purple of the red end of the spectrum, while there is minimum production under the blue rays. The rays between the lines A and E are the most beneficial. These rays encourage the production of female worms, and also the fertility of the latter. Blue rays produce 68 per cent. of males. The number of eggs laid by females reared in the "warm" rays is double that laid by females under the influence of blue light. E. E. F.

52. *Polarisation in Twisted Media.* **A. W. Ewell.** (Amer. Journ. Sci. 8. pp. 89–100, August, 1899.)—Glass is an unsatisfactory material for experiments on the rotatory polarisation of light in twisted media, since it breaks easily and usually shows double refraction, so that observations are difficult. Agar-agar, gum sandarach, gum arabic, Burgundy pitch, borax, glass and gelatine were carefully tried, but gelatine alone was found satisfactory.

Square glass plates were cemented to the ends of moderately heavy but soft rubber tubes a few centimetres long, and 12 mm. external diameter. Gelatine was reduced to a jelly by adding a suitable quantity of water, with gentle heat, and poured into these tubes through a slit in the side and allowed to cool. One of these square glass caps was placed in a square aperture at one end of a rigid frame. Over the other glass plate was slipped a circular wooden disc with an opening in the centre slightly larger than the glass cap. The jelly tubes were twisted by turning this wooden disc in the frame.

The observations with jelly, corroborated by a few experiments with glass, demonstrate that tension produces rotatory polarisation, the rotation of the plane being opposite to the twist, and a function of the twist of a degree higher than the first. E. E. F.

53. *Achromatic Polarisation and Differential Double Refraction.* **D. B. Brace.** (Phil. Mag. 48. pp. 345–360, October, 1899.)—If a ray of light polarised at 45° to the principal axes of a crystalline plate pass normally through it, the relative retardation of the components will be proportional to the thickness and to the difference in the refractive indices. In most crystals the differential double refraction in the visible spectrum is normal, and the relative retardation increases with the frequency, depending on the crystal. By crossing several such plates the difference in the resultant retardation for adjacent parts of the spectrum might be made a minimum.

The object of this investigation was to determine whether such minima existed and what orders would give the best results. Of the crystals examined, namely, Iceland spar, quartz, selenite mica, and aragonite, all were found to give more or less perfect achromatism through the greater part of the visible spectrum. The results are given of the comparisons of right- and left-handed quartz (the differential double refraction being the same whether the quartz be right- or left-handed), of selenite and left-handed quartz, of mica and left-handed quartz, of mica and selenite, of Iceland spar and left-handed quartz, and of aragonite and left-handed quartz. For example, the ratio of the orders of mica to selenite was found to be 8:7, and of mica to quartz 9:8. The results of the observations show that, with the more available crystals, achromatism cannot be obtained over the entire visible spectrum, but that certain pairs of crystals will achromatise more perfectly than others. Thus better coincidences were obtained with selenite and mica than with quartz and mica. These two pairs are particularly suitable over the others in making compound retardation plates, such as achromatic quarter-wave plates, and the orders used are comparatively low.

J. J. S.

54. *Spectra of Krypton.* **C. Runge.** (Astro-Phys. Journ. 10. pp. 73–79, August, 1899.)—Spectroscopically krypton bears a close analogy to argon. Like argon it emits two different line spectra, one with Leyden jar and spark-gap in the secondary circuit of an induction coil, the other without Leyden jar and spark-gap. As in the case of argon this latter spectrum consists on the whole of less refrangible lines, and if it were possible to fill a vacuum tube with pure krypton, the colour of the tube would probably change from yellow to blue, when the Leyden jar and the spark-gap are interposed. But there seem to be no means as yet of getting rid of the admixture of argon.

The author describes an unexplained explosion which takes place when the oxygen is removed from liquid air, and the remaining nitrogen is sparked. Certain carbon bands which remain are identical with those attributed to "metargon." These bands resist even sparking into oxygen over a solution of potash. With low pressure the carbon bands are greatly reduced in intensity. The krypton lines are also weakened, and the lines of the blue spectrum of argon make their appearance. With a Leyden jar and a spark-gap the spectrum of krypton changes as well as the spectrum of argon. The new lines are mostly in the blue part of the spectrum. The author gives a list of 47 krypton lines without a jar and a spark-gap. The strongest are at 4319·76, 4454·07, 4463·82, and 4502·43 A.U. To select the lines due to krypton he compared the photographs with photographs taken some years ago by Paschen and himself of the spectrum of argon. On each of the two plates to be compared he removed the gelatine on one side of a straight line, cutting the lines of the spectrum at right angles. The plates were then laid together in such a manner that the parts where the emulsion was left were in contact along the cut, but on different sides. In this way the plates can be examined under the microscope and the lines that exist only on one of the plates are detected. None of the lines were measured visually.

E. E. F.

55. *Spectrum of Radium.* **E. Demarçay.** (Comptes Rendus, 129. pp. 716–717, November 6, 1899.)—An account of the photographic spectrum of radium obtained from specimens of barium chloride containing radium. The wave-lengths of fifteen of the strongest of the new rays are given; many of them are as strong as the strongest of those of barium. All the lines are narrow and sharply defined, and resemble those of barium.

J. J. S.

56. *Titanium for Comparison Spectra.* **E. B. Frost.** (Astro-Phys. Journ. 10 pp. 207–208, October, 1899.)—The spark spectrum of titanium shows a large number of very sharp lines, very uniformly distributed throughout the spectrum from λ 4200 to λ 5000, and free from air lines. The spark passes

much more steadily between titanium electrodes than in the case of iron, and considerably shorter exposures are required—less than ten seconds as the apparatus is usually arranged. The consumption of the element is very slight, and it is only necessary to occasionally brighten up the points of the electrodes. Titanium is, therefore, very useful for comparison spectra, especially in astronomical work. E. E. F.

57. *Diffraction of Röntgen Rays.* **C. H. Wind.** (Wied. Ann. 68. 4. pp. 896–901, August, 1899.)—In further discussion of the interpretation of Fomm's experiment (see 1899, Abstract No. 1871), the author denies that it follows, from the low wave-lengths obtained that the rays are really some 3,000 times shorter than those of yellow light. Diffraction images like those obtained can also be produced by proper vibrations of any frequency, even that of ordinary light, if only these vibrations experience quite irregular changes of phase, with intervals between them corresponding to the frequencies resulting from the diffraction phenomena. They may also be produced by any very irregular process within the source, provided the radiation emitted by any point leads, for any larger interval from zero time to the time 2T, to a series like

$$\frac{1}{T}\sum_{n=1}^{n=inf}\left(A_n \sin\frac{n\pi t}{T}+B_n \cos\frac{n\pi t}{T}\right)$$

where the coefficients A_n and B_n are of the same order of magnitude over the whole range of wave-lengths in question, and only decrease to any considerable extent outside that range. E. E. F.

58. *Glass and Röntgen Rays.* **O. Schott.** (Zeitschr. Instrumentenk., Beib. 18. pp. 111–118, July 1, 1899.)—Glass containing soda (natron) 10 per cent., boracic acid 30, alumina 20, arsenic acid 0·4, and silicic acid 39·6 per cent., is exceedingly transparent to Röntgen rays. Platinum wire put through glass makes a tight joint if the exceedingly fine rift produced by inequalities in the expansion be filled by heavy mineral oil drawn in by capillary imbibition, so long as the rift is caused by the glass having a smaller coefficient of expansion than the glass. A. D.

59. *Diffusion of Ions into Gases.* **J. S. Townsend.** (Roy. Soc., Proc. 65. pp. 192–196, July, 1899.)—Loss of conductivity by Röntgenised gas left to itself is due partly to recombination of positive and negative ions, partly to discharge of charged ions by the walls of the vessel. Consider the ions as being equivalent to a separate gas. The charged ions diffusing to the (metallic) walls of the vessel may be regarded as absorbed by them, as moisture is when a gas bubbles through sulphuric acid. If the Röntgenised gas be passed through metallic tubing this action at the bounding surface is great in comparison with the effect of recombination. The problem thus becomes, in order to obtain the coefficient of diffusion, to find, if a small quantity of gas A is mixed with another gas B, and the mixture passed along a tube the sides of which completely absorb A, what quantity of gas A emerges from the tube along with B. The result is: if k be the coefficient of diffusion of the ions into the gas B; a the radius of the tube and z its length; V the mean velocity of the gas (*i.e.*, total volume flowing in time

$l=\pi a^2Vt$); that the ratio of the number of ions emerging from the tube to those entering it is—

$$R=4\left\{0·1952\epsilon^{-\frac{7·313kz}{2a^2v}}+0·0243\epsilon^{-\frac{44·5kz}{2a^2v}}+\&c.\right\}$$

the terms of the series beyond the second being too small to be taken into consideration. The coefficients of diffusion of ions differ from gas to gas, and are not the same in moist and dry gases. For dry air they are 0·0274 for positive ions and 0·042 for negative; for moist air 0·032 positive, 0·035 negative. For oxygen, dry, 0·025 positive, 0·0396 negative; moist, 0·0288 positive, 0·0358 negative. For carbonic acid, dry, 0·023 positive, 0·026 negative; moist, 0·0245 positive, 0·0255 negative. For hydrogen, dry, 0·123 positive, 0·190 negative; moist, 0·128 positive, 0·142 negative.

One of the equations of motion—

$$\frac{1}{k}pu=-\frac{dp}{dx}+nXe,$$

where p is the pressure of the ions, e the charge on each ion, u the velocity of the ions under electric force X, and n the number of ions per cub. cm., gives when we take n and p as N and P ($=10^6$) at atmospheric pressure and the potential gradient 1 volt per cm. (*i.e.*, $X=\frac{1}{300}$ in c.g.s. measure), and take $dp/dx=0$, the result that—

$$Ne=3\times10^8u/k.$$

This gives the following value of Ne for dry gases: air, $1·35\times10^{10}$; oxygen, $1·25\times10^{10}$; carbonic acid, $1·30\times10^{10}$; hydrogen, $1·00\times10^{10}$. These figures are in accord with electrolytic results: the conclusion is that the charges on the ions produced by Röntgen rays in air, oxygen, carbonic acid, and hydrogen are all the same, and are equal to the charge on the hydrogen ion in a liquid electrolyte. Taking J. J. Thomson's value (6×10^{-10}) for the charge on the ion in Röntgenised hydrogen or oxygen, we have 2×10^{19} molecules in a cub. cm. of a gas, and the weight of a molecule of hydrogen equal to $4·5\times10^{-24}$ gramme. In order to show that the charge on the positive ion is equal to the charge on the negative ion, the ratio of the coefficients of diffusion must be shown to be equal to the ratio of the velocities. In spite of some results to the contrary, this seems probable, the results in question being possibly affected by moisture. A. D.

60. *Influence of Becquerel Rays upon Spark-gaps.* **J. Elster** and **H. Geitel.** (Wied. Ann. 69. 3. pp. 673–675, November, 1899.)—Proceeding from the known influence of ultra-violet light and of electric waves upon the form of discharge in a spark-gap, the authors studied the effect of the double ionisation known to be due to the Becquerel rays. A spark-gap 1 cm. wide, between a positive knob and a negative disc, was exposed to a radium preparation. The sparks or brushes of the discharge were immediately converted into a glow discharge, a violet glow surrounding the knob. The former discharge form was re-established on intercepting the Becquerel rays by means of a plate of lead. When the disc was made of semi-conducting cardboard instead of metal the gap became so sensitive that the radium preparation affected the discharge at a distance of over a metre. Unlike the case of short-wave light, it is indifferent whether the electrodes be polished or amalgamated or not, but in both cases it is found that negative brushes cannot be extinguished. Röntgen rays, like intermittent ultra-violet light, produce no effect, probably owing to their intermittence. E. E. F.

61. *Magnetic Deflection of Becquerel Rays.* **F. Giesel.** (Wied. Ann. 69. 4. pp. 834–836, December, 1899.)—The author has succeeded in producing some striking negatives showing the deflection of Becquerel rays in a magnetic field. He took flat pole-pieces and laid a sensitive plate upon them, film downwards. He placed a fresh and very active polonium preparation below the film and in contact with it. On development, the blackening was found to be concentrated just in contact with the substance and along a zone on one side of the line joining the poles. The exposure was about five minutes. Between the black patch and the black zone there were a number of dark traces resembling wavy hair attached to the central patch as a head and extending into the dark zone. These traces are very difficult to account for. They somewhat resemble the ramifications seen in some Lichtenberg figures. The same effects are obtained with radium preparations, though not in the same strength as in the case of polonium. The magnetic deflection of Becquerel rays must now be considered as proved. Elster and Geitel's negative result was obtained with a vacuum, and not in the open air.

E. E. F.

62. *Radioactivity from Becquerel Rays.* **P. Curie** and **Mme. M. P. Curie.** (Comptes Rendus, 129. pp. 714–716, November 6, 1899.)—The authors find that the rays emitted by strongly radioactive substances (such as polonium and radium) when they act on inactive substances are able to communicate radioactivity to them, and that this induced radioactivity persists for a considerable time. The radioactive matter is placed in the form of powder on a horizontal plate, and above this, at the distance of a few millimetres, the plate experimented upon is fixed. After exposure the radioactivity of the upper plate is determined by the conductivity which it communicates to air. The acquired radioactivity increases with the time of exposure, but seems to tend towards a limit. It is retained by the substance for many days, but gradually disappears. To produce the effects it is necessary to use strongly radioactive substances. Those employed were from 5,000 to 50,000 times more active than uranium, and the induced activities observed immediately after the exposure then varied from 1 to 50 times that of uranium. These activities were reduced to the tenth of their original value two or three hours after the removal of the influence. In the various substances examined (such as zinc, aluminium, lead, paper, &c.) no differences in the order of magnitude of the induced radioactivities were observed, all the substances behaved in a similar way.

The effects seem not to be due to traces of radioactive matter carried under the form of vapour or dust on to the exposed plate, but an *induced radioactivity* appears to exist, which is a sort of secondary radiation due to the rays of Becquerel. J. J. S.

63. *Atomic Weight of the Metal in Radioactive Chloride of Barium.* **Mme. S. Curie.** (Comptes Rendus, 129. pp. 760–762, November 13, 1899.)—The salts of barium directly extracted from uranium minerals are distinguished from the barium salts obtained from other minerals by their radioactivity. Examined by the spectroscope they give the rays of barium, and the atomic weight of barium is found for the metal. By suitable methods of fractionating the radioactivity may be concentrated so as to obtain products more and more active. On examining these products M. Demarçay has found the appearance of a new spectrum which in the last products attains the same intensity as that of barium. The author has determined the atomic weight of

the metal in these successive products and finds that it is greater in the case of radioactive barium than in that of ordinary barium, and that this difference increases with the activity of the product. The experiments along with those of Demarçay seem to show the actual existence of the hypothetical element *radium* possessing a higher atomic weight than that of barium. J. J. S.

64. *Diffraction of Röntgen Rays.* **C. H. Wind.** (Wied. Ann. 69. 1. p. 327, September, 1899.)—The equations in the last paper on the subject (see 1900, Abstract No. 57) are corrected in one place. The correction does not, however, influence the main conclusion. E. E. F.

65. *Thorium Radiation.* **R. B. Owens.** (Phil. Mag. 48. pp. 360–387, October, 1899.)—An account is given of an investigation of the nature of the radiation given off by thorium. The methods used are similar to those employed by Rutherford in his experiments on uranium radiation. (See 1899, Abstract No. 1001.) Thorium radiation resembles in its behaviour that given off by uranium, but there are indications that thorium radiation is not confined to so few distinct types, if indeed the number is limited. If Röntgen rays and the radiations from uranium, &c., are disturbances in the ether occasioned by the internal motion of certain constituent parts of the atom, as has been suggested, it might be expected that such disturbances would shade off with some degree of regularity from a more intense to a less intense kind, and such seems to be the case with thorium.

The principal points treated in the paper are: (1) Conditions affecting the constancy of the radiation. (2) The relation between current and electromotive force. (3) Comparison of radiations from different salts. (4) Types of radiation. (5) Selective absorption. (6) Effect of suspended particles in the path of the conduction-current. (7) Variation of conduction-current with pressure of gas. (8) Absorption of radiations in air. The thorium salts used were the oxide, sulphate, and nitrate. J. J. S.

66. *Phosphorescence at Low Temperatures.* **C. C. Trowbridge.** (Science, 10. pp. 245–249, August 25, 1899.)—Many of the experiments described are the same as those of A. and L. Lumière (see 1899, Abstract No. 551). The author arrives at some general conclusions:—

A. That the reduction of the temperature of a phosphorescing substance is accompanied by a corresponding decrease in the phosphorescent discharge.

B. That very low temperatures cause phosphorescence to linger long enough to be readily observed in a number of substances that are not visibly phosphorescent at normal and high temperatures.

C. That the production of phosphorescence in a phosphorescent substance is less when excitation occurs at low temperatures than when it takes place at high temperatures, other conditions being the same.

A number of common substances show marked phosphorescence when reduced to the temperature of liquid air and then exposed to strong light; besides ivory and paper there are gum arabic, cotton-wool, starch, white glue, celluloid, and kid-skin. E. E. F.

REFERENCE.

67. *New Speculum Metals.* **L. Mach and V. Schumann.** (Akad. Wiss., Wien., S. ber. 108. pp. 135–162, 1899.)—Full discussion of the preparation and optical advantages of a series of alloys of magnesium and aluminium in atomic proportions. A. D.

HEAT.

68. *The Energy Theory.* **J. E. Trevor.** (Journ. Phys. Chem. 3. pp. 339–348, June, 1899.)—The author defines "work equivalents," *e.g.*, increase of kinetic energy in a given mass, increase of temperature in a substance measured by the quantity of work which would have to be expended to produce the change, and so on. Then the algebraic sum of all the work and work equivalents added to any given system of bodies during any change of the system is the change of a definite function of the variables defining the state of the system, and that function is defined to be the energy.

The equation of energy in its differential form is—

$$dE=\Sigma d'W+\Sigma d'E,$$

in which every $d'W$ denotes work, and every $d'E$ work equivalent, and it is important to distinguish between them. The notation d' is used to denote that the quantity to which it is prefixed is not a function of the state variables.

Potential is then defined. For instance, work spent in transferring a quantity of heat in the ordinary thermodynamic system from a lower to a higher temperature is an increase of potential.

The present paper is mainly occupied with a generalisation of the Carnot cycle. A continuation is promised. S. H. B.

69. *Theorems of Robin and of Moutier.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 548–550, November, 1899.)—The author gives an expression for any virtual change in a system containing n components in r phases, which results in—

$$\partial\phi=Vdp-HdT,$$

in which p denotes pressure, V volume, T absolute temperature, and H entropy, and ϕ is the total thermodynamic potential.

Dealing with a univariant system, he points out that it admits of a continuous series of states of equilibrium, all having the same values of ϕ, but in which V and H are different. It follows from the above equation that for any virtual change with constant T, if V increases ϕ diminishes and *vice versâ*. This is Robin's theorem. For any virtual change with constant p, if H increases ϕ diminishes and *vice versâ*. This is Moutier's theorem. Finally he deduces the formula of Clapeyron and Clausius. S. H. B.

70. *Heat of Fusion of Naphthylamine and Diphenylamine.* **J. M. Stillmann** and **R. E. Swain.** (Zeitschr. Phys. Chem. 29. pp. 705–710, September 15, 1899.)—The following results are obtained :—

Diphenylamine. Specific heat, liquid = 0·4712
" " solid = 0·4053
Heat of fusion = 23·97
Naphthylamine. Specific heat, liquid = 0·4105
" " solid = 0·3747
Heat of fusion = 25·59

The molecular depressions of the freezing-point, calculated by means of van't Hoff's formula from these figures, are: Diphenylamine 88·8, naphthylamine 81·2, the results of freezing-point determinations being 88 and 78 respectively. The great discrepancy which formerly existed was therefore due to the inaccuracy of Battelli's determinations of the latent heats of fusion. T. E.

71. *Thermal Coefficients.* **J. E. Trevor.** (Journ. Phys. Chem. 3. pp. 523–547, November, 1899.)—In the thermodynamic system we have usually four variables dealt with, namely, p the pressure, v the volume, θ the absolute temperature, and η the entropy, of which only two are independent, and any two may be taken as independent. This gives rise to four equations of the form $f(x, y, z)=0$, in which x, y, z may stand for any three of the four, and the form of f depends on the three chosen.

Four fundamental functions are dealt with, namely, E the energy, which, using v and η for independent variables, gives rise to—

$$dE=-p\,dv+\theta\,d\eta\,;$$

$$\text{F the free energy}=E-\theta\eta\,;$$

$$\text{G the heat function}=E+pv\,;$$

$$\text{H the entropy function}=E+pv-\theta\eta.$$

The author deduces—

$$\begin{aligned}\theta\,d\eta&=B_\theta\,dv+C_v\,d\theta\\&=A_\theta\,dp+C_p\,d\theta\\&=B_p\,dv+A_v\,dp\end{aligned}$$

in which the coefficients A, B, C, are to be determined. This form the author recommends as having marked advantage over that commonly employed. He determines these coefficients in terms of E, F, G, H, and their differential coefficients with regard to p, v, θ, η, giving rise to 22 equations, including six known forms.

Finally he gives three dynamical equations—

$$\begin{aligned}-p\,dv&=I_\eta\,dp+K_p\,d\eta\\&=I_\theta\,dp+J_p\,d\theta\\&=J_\eta\,d\theta+K_\theta\,d\eta,\end{aligned}$$

and these coefficients, I, J, K, also can be expressed in terms of the fundamental functions and their derivatives.

The result is that all the derivatives of the entropy, *e.g.*, $\frac{d\eta}{dp}$ (v constant), &c., can be expressed in terms of the fundamental functions and their derivatives. The same is true of v. There remain to be added $\frac{dp}{d\theta}$ (v constant) and $\frac{dp}{d\theta}$ (η constant). S. H. B.

72. *Thermodynamics.* **K. Wesendonck.** (Wied. Ann. 69. 4. pp. 809–833 December, 1899.)—Although the majority of workers completely admit the validity of the second law of thermodynamics, some serious criticisms have been advanced against it. The author discusses several of the points at issue, without, however, having recourse to the so-called kinetic theory of heat. He points out that the main principles of Clausius are still valid, and that his inequality must be regarded as the most general form of the second law.

E. E. F.

73. *Perfect Radiator.* **W. E. Wilson.** (Astro-Phys. Journ. 10. pp. 80–86, August, 1899.)—The author measured the radiation at various temperatures of an "ideally black body" in the shape of a uniformly heated enclosure with a small opening. He found Stefan's law of radiation, $R=aT^4$, very closely verified. An estimate of the sun's effective temperature, based upon this law, places it at 11,300°. E. E. F.

74. *Solid Carbonic Acid.* **H. du Bois and A. P. Wills.** (Deutsch. Phys. Gesell., Verh. 1. pp. 168–169, June 30, 1899.)—Since the triple point of carbonic acid lies at $-57°$ and at a pressure of over 5 atmospheres, the vapour-pressure curve under less than the atmosphere can only be that of the solid snow. The authors have studied this curve, and found considerable deviations from Faraday's approximate figures. The following temperatures were obtained at various pressures (in mm. of mercury):—

P............	5	 40	 110	 225
θ	$-124°$	...... $-112°$	...... $-102°$	...... $-95°$
P............	510	 638	 760	 885
θ	$85°$	...... $-81{\cdot}5°$	...... $-79{\cdot}2°$	...... $-77°$

The coefficient $dP/d\theta$ is about half that of boiling oxygen, and double that of boiling water. As regards the practical applications of carbonic acid snow, it appears that by exhaustion to 5 mm. a temperature as low as $-125°$ can be produced. Much lower temperatures can probably be attained by further exhaustion. The resistance of a bismuth spiral at $-180°$ is 280 times its value at 0° outside a magnetic field. E. E. F.

75. *Influence of Molecular Volume on Gaseous Viscosity.* **G. Jäger.** (Akad. Wiss. Wien., S. ber. 108. pp. 447–455, 1899.)—In previous papers the author has obtained for gases the formulæ—

$$pv=RT\left\{1+4\beta(1+\tfrac{5}{8}\beta+\ldots)\right\}$$
$$\lambda=\lambda_0/(1+\tfrac{5}{8}\beta+\ldots),$$

where λ denotes the mean free path and $\beta=b/v$ is the ratio of the molecular and specific volumes: these give for the viscosity—

$$\eta=\eta_o\left\{(1+\tfrac{5}{8}\beta+\ldots)^{-1}+4\beta\right\},$$

where η_o is the viscosity for small densities. Thus for moderate densities the the viscosity is $\eta_o(1+\frac{3}{8}\beta)$, but for the liquid state it approximates to $4\eta_o$ [*if* $1+\frac{5}{8}\beta+\ldots$ becomes large when $v=b$].

The molecular forces are further assumed to affect this formula by a factor $1+k\nu$, where ν is the proportion of the molecules that have combined together, which with van der Waals' formula is approximately represented by—

$$2a/vRT\ [=27\beta T_c/4T]:$$

thus—

$$\eta=\eta_o\left\{1+\tfrac{3}{8}(1+9kT_c/2T)\beta\right\}.$$

The velocity of a colliding molecule is then considered, as to whether it is determined by the layer in which the molecule's centre was, or by that in which its point of collision was, at the previous encounter; and it is concluded that in the usual formula for the viscosity λ should be increased to the ratio 5 : 4, so that—

$$\eta_o=\tfrac{5}{12}\rho c\lambda,$$

where c is the velocity of mean square. R. E. B.

76. *Specific Heat of Non-electrolytic Solutions.* **W. F. Magie.** (Phys. Rev. 9. pp. 65–85, August, 1899.)—By an approximate consideration of a simple cycle the author shows that (*a*) the osmotic pressure of a solution is equal to its latent heat of expansion, and (*b*) the specific heats of the solvent and of the solute in a solution are constant at all concentrations, if (i.) the pressure exerted by the solute in the solution is proportional to the absolute temperature, (ii.) the work done against external pressure when some of the solvent is forced through a membrane is negligeable, (iii.) the specific heats of the solvent and solution are independent of the temperature, (iv.) the change of volume of both solution and solvent consequent on change of temperature is negligible. If condition (i.) does not hold, then neither conclusion is justified, but the cycle gives $dc/dv=td^2p/dt^2$, where c is the heat capacity of the solution and p its osmotic pressure.

The specific heats of certain solutions were determined by experimental comparison of the relative masses of each solution and the corresponding solvent which rise equally in temperature on the addition of equal amounts of heat, the liquids compared being contained in similar calorimeters and being simultaneously heated by the same current passed through coils of equal resistance. The behaviour of solutions of cane sugar, dextrose, glycerine, mannite, urea, and acetamide in water, of water and glycerine in aniline, and of urea in ethyl alcohol seems to support conclusion (*b*) as applicable to their case; but the solutions of ethyl alcohol in water and of glycerine in ethyl alcohol behave differently. It further appears that the apparent molecular heat of glycerine in aniline differs from that of glycerine in water in the ratio of 80 : 54, and the apparent molecular heat of urea in ethyl alcohol from that of urea in water in the ratio of 28 : 21, while the specific heat of water in aniline appears to be equal to 2. Thus the solute is not so entirely independent of the solvent that its energy is unaffected by the solvent. R. E. B.

77. *Specific Heat of Saturated Ether Vapour.* **K. Tsuruta.** (Phil. Mag. 48. pp. 288–297, September, 1899.)—Clausius found that this quantity at ordinary temperatures has a positive sign, although for carbon disulphide, carbon tetrachloride, chloroform, and acetone it is negative. The quantity in question, h, is calculated from the thermodynamic formula—

$$h=\frac{dv}{dT}-\frac{v}{T}+H$$

where v=latent heat of evaporation, and H is the specific heat of saturated liquid, and assumes that—

$$H=C_p,$$

the specific heat of the liquid under constant pressure. The author shows that the latter assumption is justified, but that—from the measurements of Ramsay and Young and Battelli—the value of dv/dT is a much larger (negative) quantity than Clausius supposed, and hence the value of h at temperatures between −20° and +25° is probably negative. From Ramsay and Young's measurements the author finds—

$$v=93{\cdot}27-0{\cdot}256t$$

R. A. L.

78. *Specific Heat of Gases.* **A. Leduc.** (Annal. Chim. Phys. 17. pp. 484–510, August, 1899.)—The author discusses the two specific heats of a gas in connection with the mechanical equivalent of heat. Owing to the uncertainty of the data available it is difficult to formulate general laws, but the following two principles can be very satisfactorily demonstrated :—

1. The molecular capacity for heat at constant volume is the same for gases of the same valency taken in corresponding states.

2. This capacity for heat is proportional to the number of atoms contained in the molecule.

The conception of corresponding states is likely to throw further light on the specific heats of gases.

The ratio γ decreases with rising temperature and with falling pressure. The velocity of sound increases by about 0·08 per cent. as the pressure rises from 1 to 2 atmospheres. Witkowski found an increase of 7 per cent. between 1 and 120 atmospheres, and the increase between 1 and 2 atmospheres is, according to him, 0·072 per cent., or slightly less than the above value.

E. E. F.

79. *Constants of Hexamethylene.* **S. Young** and **E. C. Fortey.** (Chem. Soc., Journ. 75. and 76. pp. 873–883, September, 1899.)—The authors have measured the vapour pressures, specific volumes, and critical constants of hexamethylene by the same methods as for isopentane (see 1899, Abstract No. 1689). The liquid was eventually purified by partially freezing it in solid carbon dioxide and ether and filtering through platinum wire gauze. Among the results are—

Melting-point	4·7°	Critical temperature	280·0°
Boiling-point (760 mm.)	80·9°	„ pressure (mm.)...	30252
Specific gravity 0°/4° ...	0·79675	„ volume	3·659

Its properties appear to be intermediate between benzene and normal hexane. The ratio of actual to theoretical density at the critical point is low (3·703 against 3·77 for the average of normal liquids).

R. A. L.

80. *Critical State.* **C. Dieterici.** (Wied. Ann. 69. 3. pp. 685–705, November, 1899.)—The author proves that van der Waals' original equation of condition is not consistent with actual observations of the critical volume, not even if the additions and extensions proposed by Jäger, Boltzmann, and van der Waals himself are taken into consideration. But the theory and observations can be brought into harmony by substituting a new law for van der Waals' cohesive pressure. The author assumes that the work expended against cohesion is proportional to the pressure. But this assumption, though consistent with facts, lacks theoretical explanation. The fundamental conceptions of van der Waals may also be introduced into the formulæ of the kinetic theory. Another set of equations of condition are thus obtained, which are also quite consistent with the results of observation. The author has put these two methods side by side. Subsequent work will have to show which of the two forms corresponds most closely to actual facts observed under varied conditions.

E. E. F.

81. *Properties of Partially Miscible Liquids.* **R. A. Lehfeldt.** (Phil. Mag. 47. pp. 284–296, 1899.)—The pair chosen for investigation were phenol and water, mixtures of which are homogeneous in any proportions below 70° C. Four different arrangements of apparatus were employed, one of which is very suitable for indicating differences of pressure; and these all gave results in practical agreement. Curves are drawn showing the variation of the vapour-pressure with the percentage of phenol in the mixture at 50°, 75°, and 90° C., and a curve also showing the variation of the concentration with the temperature under the pressure of 1 atmosphere. A noteworthy result observed is that phenol added to water up to 60 or 70 per cent. makes practically no difference to the vapour-pressure of the water, so that within this long range the isothermals are very flat. (See 1899, Abstract No. 61.) R. E. B.

82. *Freezing and Boiling Water Simultaneously.* **R. W. Quick.** (Phys. Rev. 9. pp. 121–122, August, 1899.)—A lecture experiment. Instead of freezing and boiling water simultaneously by means of the air-pump, the author first boils a flask of water until free from dissolved air, then corks the flask, inverts it and applies ether to which solid carbon dioxide has been added.

W. R. C.

83. *Absorption of Heat by Water in Motion.* **G. Halliday.** (Engineer, 87. pp. 473–474, and 88. p. 20, July 7, 1899.)—Experiments are recounted from which it appears that the amount of heat absorbed by water as it passes through a glass or metal tube, which is heated on the outside by steam or hot gases, depends upon the rate of flow, and that, as this rate increases, the absorption first increases to a maximum and then diminishes, the critical rate of flow depending upon the nature of the source of heat and possibly also on the kind of motion which the water has in the tube. The quantitative relation of the heat-supply to the heat-absorption is not investigated. R. E. B.

84. *Conduction and Radiation in Gases.* **M. S. R. v. Smolan.** (Akad. Wiss. Wien., S. ber. 108. pp. 5–23, 1899.)—A continuation of the work referred to in Abstract No. 1139 (1898). At the boundary between a solid and gas, across which a flow of heat takes place, there is an abrupt change of temperature. This, when the whole temperature difference is small, may be expressed as an imaginary length which must be added to the thickness of gas through which conduction is taking place. Measurements were made, by means of thermojunctions, of the distribution of temperature between two concentric cylinders, the inner of which was cooled to 8° by a current of water, while the outer was at atmospheric temperature (15°–18°), a thin concentric metal sheet being interposed. It was found that the imaginary thickness γ was $0{\cdot}000112 \times \frac{760}{p}$ cm. for a nickelled surface in contact with hydrogen, $0{\cdot}0000153 \times \frac{760}{p}$ for air and $0{\cdot}0000127 \times \frac{760}{p}$ for carbon dioxide, where p is the pressure of the gas. The lengths are therefore proportional to the mean free path, being 6·98 times as long for hydrogen, 1·70 for air.

A previous experiment by Winkelmann may be successfully interpreted by the hypothesis of the author, and gives concordant figures.

The form of γ, which has already been shown to accord with the equation deduced from Clausius' molecular theory, is here shown to agree also with that of Maxwell. The difference between the two theories is only in the value of the numerical constants. R. A. L.

85. *Practical Thermometric Standard.* **H. L. Callendar.** (Phil. Mag. 48. pp. 519–547, December, 1899. Paper read before the British Association.)—The author suggests the adoption, for a practical standard of reference, of a scale of temperature t (to be called the B.A. scale) defined by $t - pt = dt(t - 100)$, where $pt = 100\,(R - R_0)/(R_{100} - R_0)$ and d is a constant, R, R_0 and R_{100} being the electrical resistances of a particular platinum wire at t, 0° and 100° C. respectively, and the value of d being obtained by taking the B.P. of sulphur under 76 cm. of mercury at 0° C. as 444·58° C. This scale is subject to far less uncertainty, especially at high temperatures, than that practically obtained with gas-thermometers as at present constructed and used (as the history of the investigation of the B.P. of zinc shows): it is easily and accurately repro-

ducible and is a very close approximation to the Kelvin absolute scale, its exact relationship to which would be a subject for future experiment.

The necessity for adopting a *practical* standard is first shown, and the grounds stated for the selection of *platinum* as standard: the expansion, calorimetric, thermoelectric, and resistance-methods of employing platinum are then compared to the distinct advantage of the last from every point of view, and the construction and standardising of resistance-thermometers are discussed. A strong plea for the employment of constant pressure instead of constant volume in gas-thermometers is then put forward, and for the use of helium in place of hydrogen or nitrogen, and the correction for expansion of the bulb of such thermometers is discussed.

The following selected fusing- and boiling-points on the proposed B.A. scale are given :—

Tin	F.P.	231·9	Aniline	B.P.	184·1
Bismuth	„	269·2	Naphthalene	„	218·0
Cadmium	„	320·7	Benzophenone	„	305·8
Lead	„	327·7	Mercury	„	356·7
Zinc	„	419·0	Sulphur	„	444·5
Antimony	„	629·5	Cadmium	„	756
Aluminium	„	654·5	Zinc	„	916

R. E. B.

86. *Gas Thermometer for High Temperatures.* **L. Holborn** and **A. L. Day.** (Amer. Journ. Sci. 8. pp. 165–193, September, 1899.)—Up to 500° C. bulbs of Jena borosilicate glass No. 59^{III} with enclosed hydrogen prove exceedingly satisfactory, no appreciable changes in the zero point being shown after repeated heatings. Porcelain bulbs, whether glazed inside and out or outside only, and whether containing hydrogen or nitrogen, were unsatisfactory, as their zero point rose slightly after each heating and the expansion-coefficient between 0° and 100° often exhibited unaccountable variations. These were employed up to 1100°. Platin-iridium bulbs filled with chemically pure nitrogen, which were tested up to 1300°, were found to be entirely satisfactory when heated electrically; they showed a constancy of the zero point and of the expansion-coefficient which was equalled only by that of glass bulbs at comparatively low temperatures. For this result however electrical heating is requisite, since, if combustion products are present, they rapidly pass through the wall of the bulb, even against an excess of pressure: this heating was effected by passing an electric current through a coil of nickel wire wound upon a thin tube of porcelain or clay.

For comparison of the readings of the gas thermometers a platinum platin-rhodium thermo-element was also employed in every experiment.

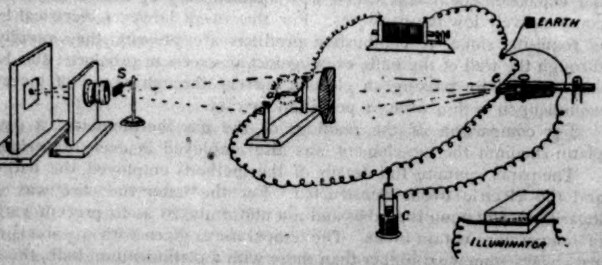
The paper contains full details of the methods employed, the baths used and the electric ovens constructed. For the latter the wire was wound logarithmically upon the tubes and not uniformly, so as to prevent variations of temperature within them. The temperatures given with a porcelain bulb are always somewhat higher than those with a platin-iridium bulb, the difference amounting to 8·5° at 1150°. R. E. B.

87. *Measurement of Extreme Temperatures.* **H. L. Callendar.** (Nature, 59. pp. 494–497, and 519–522, 1899.)—A Royal Institution lecture giving a history of pyrometric methods, and an outline of proposed new forms of air thermometers, especially one depending on measurement of transpiration by a Wheatstone's bridge method. R. A. L.

SOUND.

88. *Notes of Highest Pitch.* **R. Koenig.** (Wied. Ann. 69. 3. pp. 626–660, November, and 69. 4. pp. 721–788, December, 1899.)—Kundt's dust figures offer an admirable means of accurately determining the pitches of tuning-forks of pitches high above the limits of audibility. The fork c^7, placed at the mouth of a tube with a length of some 95 semi-wave-lengths, and a diameter of about one semi-wave-length (11 mm.) gives very clearly defined figures. The method is available up to f^9 (90,000 complete vibrations per second), a pitch which is over an octave above the extreme limit of audibility. The method of beats ceases to be practicably available two octaves below that limit. The author also studied the various means of producing notes of the highest pitches. Rods vibrating transversely are less disturbed by the method of fixture than any other class of bodies. The audibility of their notes is about the same as that of tuning-fork notes. Longitudinally vibrating rods are not available beyond a^5, since their transverse tones then begin to interfere. The notes of vibrating plates are too feeble for determining the limit of audibility, and are greatly influenced by the manner of fixture. The notes of high organ-pipes greatly depend upon the strength of the blast, but they obey Cavaillé Coll's law very closely. They show further that the audibility of a note depends largely upon its duration. Strings and membranes are quite unsuitable for producing high notes. As regards sirens, they are excellent for producing strong notes of high pitch, but care must be taken to have the blast strong enough to enable it to traverse the holes in the disc. E. E. F.

89. *Photography of Sound Waves.* **R. W. Wood.** (Phil. Mag. 48. pp. 218–227, August, 1899.)—The waves are photographed by a method based upon Toepler's "Schlieren" or striæ. A linear source of light, *e*, is obtained by allowing sparks from an induction coil to play between magnesium ribbons pressed between glass plates. This source is focussed upon a slit *s*, which stands in front of a camera focussed upon the spark-gap *aa*. The waves produced by the spark alter the density of the air, and certain densities hinder the rays from passing the slit. There will therefore be dark lines on the screen corresponding to those densities. A great variety of sound experiments may be made with this apparatus and a good lens, and the laws of reflection and refraction may be illustrated. E. E. F.



90. *Measurement of Sound.* **J. Cauro.** (Journ. de Physique, 8. pp. 483–485, September, 1899.)—To obtain uniform sounds the author adopts two different systems. In the first he employs tubes driven by compressed air enclosed in a steel tube provided with a double Fournier regulator. It gives a remarkably steady sound, but has the inconvenience of a movement of translation of the air. In another arrangement he uses an electrically driven Mercadier tuning-fork acting upon a resonance box, and only uses the sound proceeding from the box (the fork being screened). To measure the intensity of the sound he observes the vibrations produced by it in a microscope. A piece of goldbeater's skin treated with caoutchouc is mounted on a small drum. A very light disc of glass is stuck in the centre. It carries a light glass rod to the end of which is attached a piece of perforated tinfoil. A source of light is placed behind the perforation and observed with the micrometer-microscope. The motion is easily measured, and may be analysed stroboscopically. A test with Lisajous's figures shows that the disc vibrates in unison with the source, and not in one of the harmonics. E. E. F.

91. *Vibration of Telephone Diaphragms.* **J. Cauro.** (Journ. de Physique, 8. pp. 485–486, September, 1899.)—Newton's rings are used for studying the vibrations of the disc. The rings are blurred as soon as the telephone is acting. A stroboscopic analysis restores them, and their changes may be made as slow as required. The phenomenon is, however, too minute for studying the elements of the sounds or the relation between loudness and current intensity. E. E. F.

92. *Longitudinal Vibrations of Caoutchouc Fibres.* **V. von Lang.** (Wied. Ann. 69. 4. pp. 804–808, December, 1899.)—Next to the transverse vibrations (see 1899, Abstract No. 1697) the longitudinal vibrations of caoutchouc are of interest. They were determined under various tensions by comparing the pitches of the transverse (n) and the longitudinal (n') notes. The ratio of these is within the limits chosen independent of the length. It may be represented by the formula—

$$\frac{n'}{n}=\sqrt{\frac{l\,\sigma}{\lambda\,s}}$$

where s is the load and λ is the elongation of the length l, produced by a small additional weight σ. E. E. F.

ELECTRICITY.

93. *Elementary Law of Electrodynamics.* **F. Kerntler.** (Journ. de Physique, 8. pp. 556–562, October, 1899, and Écl. Électr. 21. pp. 153–156, October 28, 1899.)—The author discusses the formula of Ampère expressing the elementary law of electrodynamics, and brings forward alternative formulæ. The possibility of the establishment by experiment of the electrodynamic law proposed by the author is considered. J. J. S.

94. *Electromagnetic Fallacy.* **E. Lecher.** (Wied. Ann. 69. 4. pp. 781–787, December, 1899.)—The author criticises König's conclusions from his experiment on the continuous rotation of a magnetic pole about a conductor traversed by an electric current. He maintains that a magnetic pole does not rotate along the lines of force due to a current, and that all alleged rotations of this kind are due to secondary causes. He proves this by a simple modification of the so-called fundamental experiment, and points out that all theoretical explanations offered neglect the presence of the other pole. E. E. F.

95. *Electrostatic and Electromagnetic Induction.* **W. de Nikolaïève.** (Écl. Électr. 20. pp. 10–14, July 8th, and pp. 53–58, July 15, 1899.)—This is an academical paper upon electrostatic and electromagnetic induction. It does not lay claim to originality, but it reviews some of the theories of Quincke, Poynting, and Ewing. The basis of the argument is that the transformation of lines of force and the change of tensions and pressures in the passage from one medium (air) to another (iron) is sufficient, without further assumption, to explain all the effects of magnetic induction and the movements of paramagnetic and diamagnetic bodies in a magnetic field. R. A.

96. *Electromagnetic Theory.* **P. S. Wedell-Wedellsborg.** (Zeitschr. Phys. Chem. 29. pp. 494–497, 1899.)—According to Maxwell's theory a stationary electric current gives rise in its neighbourhood to two fields of force —a magnetic field which depends on the strength of the current, and an electric field which depends on the electromotive force. J. J. Thomson is quoted as saying that a stationary current can flow through a long cylindrical conductor of finite section without causing on the surface of the conductor any superficial distribution.

The writer replies to A. Scheye and discusses these theories. He contends that Maxwell's theory leads to inconsistencies. He contends also that to Faraday, not to Maxwell, is due the conception of light being an electromagnetic phenomenon, and considers that Faraday's conception of ether agrees better with aberration phenomena than Maxwell's.

Reference is also made to Ostwald's theory, according to which the sun radiates energy only to colder bodies, and this he says agrees with Faraday's conception of ether and also with some views of J. J. Thomson. S. H. B.

97. *Ohm's Law.* **R. Mewes.** (Elektrochem. Ztschr. 6. pp. 155–158, November, 1899.)—In the treatises "Physik des Aethers" and "Licht, Elektrizitats—und X—Strahlen" the author has dealt with a dynamical theory of the ether explaining among other things thermoelectric phenomena in metals. The present paper contains an explanation of Ohm's law in the light of the same theory. J. B. H.

98. *Origin of Frictional Electrification.* **C. Christiansen.** (Wied. Ann. 69. 3. pp. 661–672, November, 1899.)—This is the author's fourth communication on the subject. He studied the difference of potential jets of mercury and of zinc amalgam or other amalgam falling side by side through dry or moist oxygen. A mercury jet was surrounded by 12 jets of the amalgam, containing very little of the foreign metal—say 0·1 per cent. The rate of efflux of the amalgam jet was about 2 m. per second, and as the unbroken mercury jet was 18 mm. long, the amalgam opposite the end of the mercury jet had been exposed to the oxygen for about 0·01 second at the point of measurement. As long as the oxygen was somewhat moist, the normal difference of potential of 0·88 volt was indicated between the amalgam and the mercury. But when the moisture was gradually reduced the difference of potential steadily decreased, and finally was reversed in sign at a point where the vapour pressure was about 0·5 mm. This indicates that the amalgam forms a hydrate in moist air and an oxide in dry air. Magnesium amalgam shows a higher difference of potential, both positive and negative. Cadmium amalgam shows about the same as zinc, and lead amalgam less. The negative values of the differences of potential are very indefinite, as it is extremely difficult to employ absolutely dry oxygen. E. E. F.

99. *Electric Figures.* **P. de Heen.** (Comptes Rendus, 129. pp. 717–719, November 6, 1899.)—When an electrified plate of resin is sprinkled with powdered sulphur Lichtenberg's figures are obtained. If around such an electrified plate there be arranged centres of disturbance of the ether, such as flames or electric tufts proceeding from points placed in communication with a coil, the effect is exactly as if the electric energy was driven back by each of these sources and as if they emitted a peculiar wind. Also the electricity disposes itself along the geometrical figures which would be got on projecting on to a plane liquid jets, which on extending themselves into sheets produce the well-known figures. If two foci of projection are used a straight line results, three foci will produce three straight lines meeting in a point, jets arranged in the form of a square will produce squares, when in hexagonal form, triangles. In general the figure obtained may be expressed thus: the geometrical locus is formed of points at equal distance from two foci, the common distance being less to every other focus.

The figures are obtained in a few moments on placing above an electrified plate a series of gas-jets very small and arranged like the jets of water referred to above. The effect is as if these sources gave out an ethereal breath or wind, which on meeting the sheet of resin would carry away the electric energy as a puff of wind carries away dust. Analogous effects may be obtained by using the rays given out by air which has been submitted to the action of Röntgen rays. J. J. S.

100. *Charge of Arc Light Vapours.* **C. Chéneveau.** (Écl. Électr. 20. pp. 401–404, September 16, 1899.)—A vertical "arc" is made to play between a cylinder of one metal and a tube of the same or another metal mounted above it and concentric with it. The vapours from the arc mount upwards through the tube and are led into a Faraday cylinder connected with a quadrant electrometer. The latter always shows a deflection, which usually persists for some time after the arc has been interrupted. When the cylinder is the positive pole the charge indicated is negative and *vice versâ*. The author supposes that the positive pole attracts the negative ions in the vapour, and sends them into the cylinder in numbers exceeding the positive

ions. He proposes to try the experiment of separating the constituents of an ionised vapour by an ordinary electrostatic field. The present experiments were made with copper, zinc, brass, carbon, and mercury. E. E. F.

101. *Electrostatic Rotations.* **R. Arnò.** (Accad. Lincei, Atti, 8. pp. 167–168, September 17, 1899.)—A horizontal metallic plate is divided into three equal sectors, each of which is placed in connection with one terminal of a three-phase circuit. A paraffined cardboard disc is mounted on a point 9 mm. above the metal plate, the latter being 12 cm. in diameter. On working the circuit with an effective difference of potential of 3,000 volts between one terminal and the next, the cardboard disc is set into very rapid rotation. E. E. F.

102. *Moving Bodies in an Electric Field.* **A. Heydweiller.** (Wied. Ann. 69. 3. pp. 531–575, November, 1899.)—If a sphere rotates uniformly in a medium of different conductivity subject to electric stress, a couple acts upon the sphere tending to stop or to accelerate its motion, accordingly as the conductivity of the medium is very small or very large in comparison with that of the sphere. The author has repeated the experiments of Quincke, Arnò, Threlfall, and others made in this connection. He finds that the phenomena in air are complicated by its dielectric conductivity. This conductivity depends upon the field intensity on the one hand and upon the density on the other hand, increasing with increasing field intensity and with decreasing density. A maximum is reached at a pressure of about 0·005 mm. of mercury. The conductivity may, according to these conditions, be greater or less than that of a glass sphere or plate suspended in it, and the rotations or oscillations observed will vary accordingly. The author applies this observation to the motion of celestial bodies, which may be regarded as conducting spheres suspended in a non-conducting medium strained by a feeble electrostatic field. He shows that if the earth's potential was 10^7 as at present, or somewhat higher, say 10^{10} electrostatic units, for 100 billion years, the field thus created would account for the stoppage of the moon's rotation without having to call in a supposed tidal action. E. E. F.

103. *Brush Discharge in a Magnetic Field.* **M. Toepler.** (Wied. Ann. 69. 3. pp. 680–684, November, 1899.)—Every discharge in the open air is more or less influenced by a magnetic field. The effect may be produced in a peculiarly striking way by producing a negative "brush discharge arc" between a blunt brass point and a slate, and introducing a high water-resistance into the circuit. The discharge is directed between the pole-pieces of an electromagnet. The magnetic field has the effect of crowding the stratifications together, and also of displacing them laterally with respect to each other. An unstable brush discharge is converted into a spark discharge by the magnetic field. E. E. F.

104. *Ions in the Electric Wind.* **A. P. Chattock.** (Phil. Mag. 48. pp. 401–420, November, 1899. Portion read at Bristol Meeting of the British Association, 1898.)—When an electric discharge passes continuously through the air between a point and a plate an increase of pressure is experienced on the side of the plate nearest the point. This pressure is given by the equation

$$V = Cz/(P - \pi)$$

where V is the velocity of the ions in unit electrostatic field, C is the current passing between the point and the plate, z the distance from the point to the plate, P the total increase of pressure on the plate (due partly to impact of ions themselves and partly to the drag of the ions on the air), and π is the pressure due to the impact of ions alone. All these quantities may be experimentally measured except V, which is therefore determined: π is obtained on the assumption that in the air at ordinary pressure the ions give up the greater part of their momentum very near the point, and so a curve of P plotted with z as variable should be a straight line cutting the axis of P in π. The total pressure P is experimentally determined here by plotting the pressures on the plate at different distances from the foot of the perpendicular from the point. A small hole in the centre of the plate allows the pressure at that point to be measured on a manometer, a metal tube being soldered to the back of the plate and surrounding the hole, and connected by indiarubber tubing with the manometer. The point is moved parallel to the plate and the pressures corresponding to its different positions are read on the manometer and then plotted. The integration of the curve gives the total pressure P. The current from the point to the plate is measured on a galvanometer and is always kept constant. Plotting the values of P for different values of z gives a straight line cutting the axis of P in π. In the experiments the strength of the field was practically uniform everywhere except close to the point. (In some experiments the point had a guard ring surrounding it and in electrical contact with it.) This was shown by plotting the difference of potential between plate and point with z as abscissæ; the result being two straight lines, one for + discharge and the other for − discharge.

The velocities calculated from the results of the experiments are—

$$V+ = 336 \text{ cm/sec.}$$
$$V- = 489 \text{ cm/sec.}$$

Another method of experimenting is described, in which the plate is replaced by a thin ring, and the point and ring are placed coaxially in a wide glass tube closed at both ends. Two side tubes at the two ends communicate with the two limbs of a manometer which registers the difference of pressure when the discharge takes place: z is varied by moving the ring along the axis of the tube. In this case

$$P = pa + p'$$

where p is the difference of pressure measured on the gauge, a the area of cross-section of the wide glass tube, and p' that portion of the pressure stopped by the ring.

The mean values obtained for the velocities are—

$$V+ = 413 \text{ cm/sec. in unit E.S. field}$$
$$V- = 540 \quad ,, \quad ,, \quad ,,$$

The other points dealt with in the paper are (1) the relation between the velocity of the ions and that of the wind; (2) the spread of the current between point and plate; (3) the mass of the ions. J. B. H.

105. *Electric Discharge by Light.* **O. Knoblauch.** (Zeitschr. Phys. Chem. 29. pp. 527–545, July 28, 1899.)—The cause of the loss of a negative charge from some bodies when light is allowed to fall on their surfaces is here investigated. The experimental method adopted is that which was used by Elster and Geitel and by others in their experiments on the same phenomena. About sixty different organic and inorganic compounds were experimented

on, and the results are given in tabular form in the paper. The substances were not chosen at random, many of them being taken because of the effect of light on their chemical constitution.

The results may be best summarised on the theory of oxidation and charged ions which the author accepts. Reducing agents and bodies not fully oxidised when illuminated lose their negative charges the most rapidly; oxidising agents and bodies fully oxidised do not lose their negative charge. In no case did any body lose a positive charge any quicker when illuminated than when not. Some bodies which oxidise very readily and do not lose any negative charge, the author considers to be already fully oxidised on the surface. He also applies the theory to those bodies which have their chemical constitution altered by light, *e.g.*, AgCl and AgBr, and considers that the primary action in the chemical change is one of oxidation, the evolution of Cl and Br in the above being secondary phenomena.

The oxidation is considered to be due to the action of the light on the film of condensed gas on the surface of the bodies, causing ionisation of the gas in the film. The traces of this film which always adhere even in atmospheres of other gases account for the loss of negative charge which takes place in these atmospheres.

The author also applies the oxidation theory to explain (1) the positive electrification of an insulated Zn plate when light falls on it, (2) the electric conductivity of air surrounding phosphorus, (3) the effect of a beam of light falling on the kathode in rarefied gases acting as a promoter of discharge, and (4) he criticises adversely the suggestion that the rate of loss of a negative charge by a coloured substance should be a measure of the permanence of the colour in sunlight. J. B. H.

106. *Explosive Effect of Electrical Discharges.* **J. Trowbridge, T. C. McKay,** and **J. C. Howe.** (Phil. Mag. 48. pp. 279–286, September, 1899; Amer. Journ. Sci. 8. pp. 239–244, October, 1899.)—Experiments over a wide range of high voltages show that the explosive effect of electrical discharges is due to an electrostatic effect rather than to a heat effect: that a strong analogy exists between the terminal conditions existing in electrical discharges and those of the electrodes of an ordinary voltaic cell in respect of an ionisation and electric attraction and repulsion of the particles of the air which is, however, a local phenomenon; that the electric density on the terminals of a condenser is proportional to the strength of current which the charging battery is capable of producing; and that the electrostatic field, diminishing much more rapidly with the distance than the electromagnetic field, doubtless has its energy consumed in molecular movements. A. D.

107. *Cooling in Sparked Air.* **P. Pettinelli.** (N. Cimento, 10. pp. 117–120, August, 1899.)—A thermometer, in air through which a few oscillating sparks from a Ruhmkorff coil (2 to 3 cm.) have been passed, takes about one-thirtieth less time to cool than it takes in ordinary air. A. D.

108. *Pressure within the Spark.* **J. F. Mohler.** (Astro-Phys. Journ. 10. pp. 202–206, October, 1899.)—Experiments were made to test the results obtained by Haschek and Mache. (See 1899, Abstract No. 1891.) If their results are near the truth the shift of the lines due to pressure should be very considerable; indeed, as in many experiments they found a pressure of more than 50 atmospheres, the displacement of the lines should be four or five

times the largest displacement found by the authors in previous experiments with the arc, for the displacement due to 1 atmosphere is a measurable quantity with some elements. The author used a 4-inch concave Rowland grating, mounted in the usual way on piers of solid masonry, in a room of nearly constant temperature. Photographs of the spectrum under consideration were taken along with the spectrum of the arc, at atmospheric pressure, for comparison. The results show that there is pressure produced when the spark passes through a medium, but that it is not nearly so great as supposed from the work of Haschek and Mache. The results also show that the amount of pressure varies with the density of the medium surrounding the electrodes, and that the kind of gas does not affect the result. With a medium such as water, 800 times as dense as air, with a small capacity a displacement of about 0·4 Ångström unit would be produced in the iron lines, which is only a little less than the average displacement of the lines obtained by Wilsing. E. E. F.

109. *Rapid Spark-Discharges.* **H. T. Simon.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 2. pp. 183–186, 1899.)—A large induction-coil usually gives a crackling, brilliant, zigzag-shaped spark discharge; but when it is provided with a rapid interrupter (*e.g.*, Wehnelt's) the discharge takes the form of a flaring bow which exhibits no zigzags. Instead of crackling it hisses, the colour of the light is changed, and the brilliancy is much diminished. This "flame-bow" can extend much beyond the usual sparking distance of the coil. If the spark-gap is horizontal the flame-bow is bent upwards by the current of warm air which it produces; the length of its path goes on increasing until it breaks off and starts again lower down. If the discharge takes place between two rods inclined to one another so that the distance between them increases upwards, the discharge begins at the bottom and then slides upwards (until the distance is increased four or five times), snaps, and starts again across the shortest path. (This illustrates the action of certain forms of lightning-protector.) If air is blown into such a flame-bow it passes over into the zigzag spark-discharge. Photographs show that the latter consists of separate sparks, each of which has a jagged path. The flame-bow also consists of separate sparks, but all of these have a twisted, wave-like appearance, and each one follows very approximately the path of the spark which precedes it. When photographed on a moving plate the separate spark-paths appear as approximately parallel curves. Thus when the sparks follow each other rapidly enough, each one finds its path prepared by the preceding one. This preparation must be of the nature of a physical change in the air which only lasts for a short time. The author has determined this time photographically, for air at rest and at ordinary pressure. He finds that a spark follows the path of the preceding spark so long as the interval between them does not exceed 0·0028 second; if it exceeds this the spark follows a new zigzag path. Within wide limits this time appears to be independent of the length of the spark-gap and of the material of which the points consist. D. E. J.

110. *Current in Vacuum Tube.* **A. Righi.** (N. Cimento, 10. pp. 112–115, August, 1899.)—If there be in circuit a battery of small storage cells, a tube of rarefied gas with unequal electrodes (say a disc and a point), a sensitive galvanometer, and a high resistance (column of distilled water); and if the electromotive force of the battery be only slightly above what is required in order to send a current through and light up the vacuum tube; then it is sufficient to change

the place of the resistance in the circuit in order to modify not only the luminosity of the tube, but also the strength of the current passing through the galvanometer. The explanation suggested is that the current is not really continuous as it appears to be from the apparently continuous luminosity, but is a succession of discharges governed by the dissimilarity between the electrodes. A. D.

111. *Free Electricity on Vacuum Tubes.* **E. Riecke.** (Wied. Ann. 69. 4. pp. 788–800, December, 1899.)—To demonstrate the existence of free electric charges on the surface of vacuum tubes in action, and to study their distribution, the author employs Lichtenberg's figures. He dusts a mixture of sulphur and red lead on to glass, shakes off the mechanically adhering dust, and photographs the resulting figures. The latter differ according to whether the electrodes are put to earth or not. Just opposite the kathode a ring is formed, free from sulphur, and containing within it irregular patches of minium. A ring of red powder is formed where the plane of the kathode cuts the glass, and a cap of red powder surrounds the kathode wire. The remainder of the tube is covered more or less evenly with yellow powder. When the anode is put to earth, the powder arranges itself in bands extending towards the kathode on one side and the spot opposite the kathode on the other side. Metallic objects placed in the path of the rays cast a sharp shadow free from red powder, and sometimes covered with yellow powder. A metallic mirror produces a spot like the kathode, just as if the kathode rays had been regularly reflected. (See 1898, Abstract No. 686.) E. E. F.

112. *Death from Electric Discharges.* **J. L. Prevost** and **F. Battelli.** (Comptes Rendus, 129. pp. 651–654, October 23, 1899.)—Two hundred and seventy experiments were made upon dogs, rabbits, and guineapigs (compare 1899, Abstract No. 651), the animals being inserted in a condenser circuit, charged by a Ruhmkorff, and the electrodes placed in the mouth and rectum respectively. The fatal effect does not depend upon the direction of the current, nor upon the quantity of electricity, but is proportional to the energy (capacity and square of potential difference). The mortality did not further increase when the spark-gap exceeded 15 mm., and the effect is the same for a capacity 1 and a spark-gap of 4 cm., as for a capacity 4 and a gap of 1 cm. On the whole the number of fatal cases decreased with increasing weight and age; two consecutive discharges of 1,000 joules did not kill a dog of 7 kg. weight. Quickly consecutive discharges have an accumulative effect, but are comparatively less fatal than single discharges. Five phases are distinguished in the effects: general muscular contraction, convulsions, spasms, general inhibitions of the nervous system, stoppage of heart's action; young guineapigs cannot be revived even after the second phase by artificial respiration. The paper also refers to the fluctuations in the arterial pressure and to anatomical lesion. H. B.

113. *New Vacuum Tube Phenomenon.* **C. E. S. Phillips.** (Electrician, 43. p. 811, September 29, 1899. Abstract of paper read before the British Association at Dover.) The phenomenon is best described in the words of the original Abstract:—

"The apparatus used in this investigation consisted of an approximately spherical glass bulb, the ends of which were left open for the purpose of inserting two soft iron electrodes, half an inch in diameter, through air-tight flanges which themselves were cemented to the glass. The bulb was about 2¼ inches in diameter, and the electrodes were chosen of a sufficient length to enable them, while almost meeting at the centre of the bulb, to project outwards slightly beyond the rims of the flanges. A side tube was attached for the purpose of connecting the apparatus to a Sprengel air-pump and McLeod vacuum gauge. Two powerful electromagnets were then adjusted, so as to strongly magnetise the electrodes when necessary.

"A low pressure having been produced in the bulb by the action of the air-pump, leading wires were attached to the iron electrodes to enable the discharge from the secondary of an induction coil to be passed through the rarefied gas. Under these conditions the effects produced in the usual glow-discharges by the magnetisation of the electrodes could be conveniently examined. It was seen that at a pressure represented by 0·008 mm. of mercury, and with the discharge just able to pass in the bulb (the magnets meanwhile remaining unexcited), on shutting off the current from the induction coil and completing the magnet circuit, a luminous ring appeared within the bulb in a plane at right angles to the lines of force and in rotation about the magnetic axis. The number of such rings can be varied by special devices, and their brightness largely depends upon the electrostatic condition of the outer surface of the glass bulb. The circumferential speed of the ring or rings rapidly dies down, and the sense of the rotation reverses when the magnetic polarity of the electrodes is reversed. The rings, when once formed, usually last for many seconds, sometimes for a minute; and they momentarily brighten before disappearing, when the electrodes cease to be magnetised. The appearance of the rings is greatly affected by bringing charged bodies up to the outside of the bulb.

"The effect also depends upon the manner of stimulation of the rarefied gas within the bulb. It is necessary to obtain a particular distribution of charged particles in order to get the best results when the magnet is excited. The shape of the magnetic field is also of importance." E. E. F.

114. *Phillips' Rotation Phenomenon.* **Kelvin.** (Electrician, 43. p. 582. August 4, 1899.)—The author seeks the explanation of Phillips's rotating luminous rings in Varley's fundamental discovery of the torrent of negatively electrified particles from the kathode, when an electric current is forced through a somewhat highly exhausted glass vessel. The tendency of this may be to fill the whole space with negatively electrified particles, remaining scattered through the enclosure for some time after the cessation of the discharge. If this is the case, each of these must, during the initiation of the magnetic field, experience an electrostatic force proportional to its distance from the axis of the field, and in a direction perpendicular to the axis. This is just what is required to explain the rotating rings.

E. E. F.

115. *Repulsion of Electrodes in Vacua.* **H. Ebert.** (Deutsch. Phys. Gesell., Verh. 1. pp. 141–144, 1899.)—The repulsion of electrodes in high vacua when under the influence of an alternating discharge is not, as Neesen supposes, due to thermal expansion of the intervening gas, since hot gases ascending between movable plates produce the effect of an attraction. Moreover, the difference of potential should fall if hot gases were at work, whereas in reality it rises. The author attributes the phenomenon to residual electrical effects. E. E. F.

116. *Anode and Kathode Rays.* **A. Battelli** and **L. Magri.** (N. Cimento, 10. pp. 264–268, October, 1899.)—The authors subjected the same highly exhausted tubes to bipolar and unipolar discharges, and formulate the following rules : In every species of tube both anode and kathode rays are generated, the former proceeding from parts at higher potentials, the latter from parts at lower potentials. In the case of bipolar discharges all parts of the tube generate anode rays, except the kathode, which generates kathode rays only. But when only one electrode is connected with the machine, both anode and kathode rays are generated by the electrode connected. This may be shown by deflecting the rays by a magnet, when that portion of them which produces fluorescence of the glass is deflected like kathode rays, while the other, of the violet colour of the anode light, is deflected in the opposite direction. The anode rays have an oxidising action, while the portions of a metallic screen which are impinged upon by the kathode rays are less oxidised, probably owing to a reducing counteraction of the kathode rays. The charges conveyed by the rays generated in unipolar discharges are studied by the authors by means of an ingenious combined vacuum tube and electroscope.

E. E. F.

117. *Velocity of Kathode Rays.* **E. Wiechert.** (Wied. Ann. 69. 4. pp. 739–766, December, 1899.)—The author employs Tesla currents in a Lecher wire system, and starts the emitting and measuring systems by the same spark. The kathode rays produced are deflected by means of a loop in the condenser circuit. The kathode is hollow, and the rays are under ordinary circumstances concentrated on a hole in a diaphragm. When the Lecher system is at work, the beam is periodically deflected, and appears to be split into two beams, marking the two positions of extreme deflection. A small permanent magnet is then placed in such a position that the beam is deflected to begin with, and the hole in the diaphragm corresponds to one of the extreme positions. In this manner a strong and apparently steady beam is made to penetrate the diaphragm whenever the Lecher system is working. After passing for some distance along the tube, the beam passes through another diaphragm, behind which it is caught on the screen. The last portion of the path is surrounded by another deflecting loop. If, therefore, the velocity of the rays is beyond the resources of the arrangement, the deflection will be again in the same direction as in the first loop. But if during its passage along the tube the beam has lost phase with respect to the deflecting oscillation, the beam will show a different deflection, and the periodic change of the deflection along the tube, taken in connection with the known periodicity of the deflecting system, gives complete data for measuring the velocity of the rays.

The observations indicate that this velocity is about one-seventh of the velocity of light. The most probable value for the ratio e/m comes out as $1{\cdot}26 \times 10^7$, which is lower than the values hitherto obtained. The moving atomic weight per "electron" appears to be $\frac{1}{1300}$ of the oxygen atom.

E. E. F.

118. *The Ratio e/m.* **S. Simon.** (Wied. Ann. 69. 8. pp. 589–611, November, 1899.)—In view of the theoretical importance of the ratio of the electric charge of a kathode particle to its mass, the author has endeavoured to obtain as accurate a value as possible for this ratio. He used Kaufmann's method of transmitting a beam of kathode rays through a magnetising coil. The chief matter of importance was the task of deter-

mining accurately the variation of the magnetic field along the path of the beam, and this was done by means of a specially designed magnetometer. It was important that this field should be as uniform as possible, and that the remainder of the path should be uninfluenced by magnetic forces. For this object the position of the anode and kathode were so chosen that the resultant magnetic effect outside the coil was zero. Three independent measurements were made with different positions of the electrodes. The first and third measurements resulted in a difference of 0·43 per cent., and the first and second in a difference of only 0·1 per cent. The final value of the ratio was $1·865 \times 10^7$ c.g.s. units. Kaufmann's corrected value was $1·77 \times 10^7$. E. E. F.

119. *High-frequency Glow-light.* **H. Ebert.** (Wied. Ann. 69. 2. pp. 372–397, October, 1899.)—When a high-frequency alternating current, of, say, 1,000 reversals per second, is discharged through a vacuum tube in process of exhaustion, the current intensity increases up to a certain point of exhaustion, and then decreases. At the same time the difference of potential and the energy consumed pass through a minimum. This is explained by the author on the ground of a residual effect of the positive charge in the glow-light, which persists for a short time after the glow has ceased. When different gases are compared, it is seen that the reversal takes place at pressures which are in the same ratio as the mean free paths of the respective gaseous molecules—in other words, where the mean free path has reached a certain value. After that is reached, the charged molecules are no longer capable of exchanging their charges in time for the next discharge. A similar reversal takes place when the pressure is kept constant and the electrodes are moved up to each other. The reversal coincides with the point at which the glow-light layers formed during alternate discharges begin to overlap. When another tube is mounted in parallel, part of the discharge then begins to pass through the second tube. The author has also succeeded in demonstrating a repulsion between the electrodes, due to the fact that the positive charges produced by one anode persist after the other electrode has become an anode. E. E. F.

120. *Positive and Negative Spark-Discharge in Gases.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin., S. ber. 40 pp. 770–778, October 19, 1899.)—It is known that the spark-discharge at a negative potential is generally greater than at an equal positive potential. The effect produced on this phenomenon by the presence of slight impurities in the gases appears to have escaped notice. The author's attention was directed to it in the course of experiments on the spark-discharge in nitrogen at various negative and positive potentials. It was found that with a given negative potential the discharge current diminished with the time. *E.g.*, with a potential of—6,160 volts it diminished, in four minutes from 64·4 to 43·7 micro-amperes; when the apparatus was refilled with fresh nitrogen from the gasometer the current rose again to 62·7 and then diminished as before. Whatever the impurity was which produced this effect, it was not capable of affecting in the same way a positively charged electrode. Thus the currents given for V = 4,850 were (in micro-amperes): Positive, 2·06 at start and 1·95 next morning; negative, 40 at start and 11·2 next morning. The most likely impurity was oxygen, for although the nitrogen had been purified by potash, sulphuric acid, and phosphorus pentoxide, it had been collected in the gasometer over water, and this water would contain air. It was probable that the negative conductivity would be increased by removal of any oxygen present. It was removed by passing the

gas over copper. As long as the copper remained cold there was no change: on heating it there was a considerable increase in the negative discharge. Some of the results obtained with nitrogen purified in this manner were remarkable; *e.g.*, it was now found that the current at a negative potential of 3,310 was 200 times as strong as that at a positive potential of 5,180 volts.

D. E. J.

121. *Transmission of Hertzian Waves through Liquids.* **E. Branly.** (Comptes Rendus, 129. pp. 672–675, October 30, 1899.)—The liquids examined were contained in a cubical case 60 cm. in the side; in the liquid was immersed a wooden box containing the receiver. In order to reach the receiver the waves had to traverse a stratum of liquid 20 cm. thick. The dimensions were fixed before knowing how high the absorptive power of some of the liquids would prove to be, and it was found necessary to use two different radiators, A and B. A was used for comparing the transparency of air, oil, and water: its induction coil had a sparking distance of 2 cm., and the exciter had an air-gap of 1·2 mm. B was much more powerful, and was used for water and saline solutions: its induction coil had a sparking distance of 20 cm., and a Righi exciter with an oil-gap was used with it. The following numbers give in metres the distances (measured to the face of the case) at which the radiator just ceased to act upon the receiver:—

Radiator A.—Air, 10·3; water from the Vanne, 2·2; air, 9·5; mineral oil (valvoline), 10·5; distilled water, 3; water from the Vanne, 2·6.

Radiator B.—Water from the Vanne, 9·2, 9·5; water containing in 185 litres 1 kgm. of common salt, 0·8; water containing twice as much salt, 0·0. The latter number indicates that no effect was produced on the receiver when the radiator was right up against the face of the case.

The same quantity of sea-water would contain about 5 kgms. of common salt; apparently a layer of it much less than 20 cm. in thickness would completely absorb the waves. Sea-water would appear to stop Hertzian waves more effectually than a wall of cement of the same thickness (and, compared with cement walls, dry stone walls are very transparent).

The sulphates of zinc, sodium, and copper show absorptions which are smaller than that of common salt, but are still comparable with it. D. E. J.

122. *Behaviour of Vapours towards Tesla Oscillations.* **Kauffmann.** (Zeitschr. Elektrochem. 6. pp. 87–92, July 27, 1899.)—Vapours behave towards "Tesla oscillations" in much the same way as gases. When a tube containing only nitrobenzene vapour with excess of nitrobenzene is held over a "Tesla pole," the vapour (and the vapour only) gives out a pale green light; the liquid does not fluoresce at all. Tubes containing naphthalene give only a very feeble bluish-white light. (On the other hand, kathode rays are readily formed in them.) The luminescence is accompanied by decomposition. Nitrobenzene becomes visibly brown after its vapour has luminesced for a few minutes. Tubes after frequent use do not respond so readily. Naphthalene tubes also become brown after frequent use and no longer show kathode rays. The effect of increasing the vapour-pressure is examined by placing a tube in boiling water; of the two "Tesla poles" one is connected to the water and the other to earth. On touching the tube with the hand the following is observed: If it is a nitrobenzene tube its luminescence is greatly reduced: only green sparks pass through the vapour. If it is a naphthalene tube it exhibits a powerful violet fluorescence, visible at a considerable distance; kathode rays no longer appear. On replacing the tubes in cold water they

revert to their original behaviour—green luminescence in the case of nitrobenzene, and faint blue in the case of naphthalene. Thus increase of pressure diminishes the luminescence of some vapours while it greatly increases that of others. Examination of the behaviour of a number of vapours boiling under atmospheric pressure shows that the aromatic compounds luminesce much more strongly than the aliphatic compounds. The luminescence is shown by hydrocarbons, amines, and phenols. It is extremely faint in the case of benzene itself; much stronger in the case of naphthalene, diphenyl, anthracene, and other compounds containing more than one benzene nucleus. The remainder of the paper is chiefly of interest to the chemist. The author believes that a systematic examination of the behaviour of aromatic compounds may throw much light on their constitution. D. E. J.

123. *Propagation of Electric Oscillations in Dielectrics.* **A. Turpain.** (Comptes Rendus, 129. pp. 670–672, October 30, 1899.)—The results of the experiments made by Arons and Rubens, Cohn and Zeemann, and by Blondlot, can be equally well used to support either Maxwell's theory or Helmholtz's theory as modified by Duhem. The author has recently made experiments, the results of which—after making certain assumptions as to the effects of transversal and longitudinal displacements upon the resonator—are free from this ambiguity. His conclusions are in accordance with the Helmholtz-Duhem theory. D. E. J.

124. *Transference of Electric Waves from one Conductor to another.* **M. G. Gutton.** (Annal. Chim. Phys. 18. pp. 5–75, September, 1899.)—Various arrangements were examined in which waves in one wire induced waves in a neighbouring one. In Part I. the secondary and primary wires lay in the same line, their ends adjacent. These were formed into what were the coatings of a Leyden jar under various conditions. It was proved by numerous experiments that the phase period and damping remained unaltered in the secondary. The phase was ascertained by causing the primary and secondary to act simultaneously on the same resonator, the damping by means of Bjerknès' electrometer method.

In Part II. the primary and secondary wires lay parallel for a short portion of their length. For this purpose the two primary wires carrying the waves from either side of the oscillator were bridged across at their ends, and the secondary wires, also joined across, were placed so that for a short distance they ran close to the primary wires. It was proved by experiment that the direction of the electric force in the secondary system was reversed, a change in phase of half a period. The period and damping, as before, were proved to be unaltered. It was also shown that to get maximum effect in the secondary, the portions of the primary and secondary wires running close together should be $\frac{1}{4}\lambda$ on each side of the point of junction of the primary wires.

In Part III. the position on the primary, where the secondary wires were brought into proximity, was moved away from the end—that is, away from the position where the electric force is a minimum. The ends of the secondary being now disconnected a change in phase of half a period could be obtained, or not, according as the ends of the secondary, where the induction took place, were turned up or down the primary lines.

In Part IV. the lines of force in the neighbourhood of a resonator were experimentally studied by means of a coherer. F. T. T.

125. *Coherer Repealer.* **G. Dary.** (Électricien, 18. pp. 212–214, September 30, 1899.)—Guarini shields the receiving wire from the effects of his retransmitted signals by a metal sheath on one side. M. O'G.

126. *Measurement of Coherer Currents.* **A. Trowbridge.** (Amer. Journ. Sci. 8. pp. 199–205, September, 1899.)—An electromagnetic disturbance induces a static wave in a conductor whose direction is the same as the lines of electric force from the source of disturbance. This static wave was imitated by a condenser discharge in order to test the relation between the quantity of electricity, its potential, and the amount of cohesion. Marconi's coherer was found to give discordant results, and therefore Branly's type with bicycle balls, 9·5 mm. diameter in a glass tube was used. The resistance was adjusted to 2,000 ohms by pressure. For a constant quantity of electricity the resistance fell more when the potential applied to the coherer was higher, but below a critical potential (8 volts for this particular coherer) it did *not* fall. The potential used on the relay should be kept below this figure. The discharge was aperiodic. Reference is made to Branly (Comptes Rendus, cxi.), Dorn (Wied. Ann. 1. xvi. p. 146), and Aschkinass (Wied. Ann. xvi. p. 284). M. O'G.

127. *Action of a Coherer.* **R. Malagoli.** (N. Cimento, 10. pp. 279–282, October, 1899.)—Tommasina's discovery of conducting chains among the particles of a coherer may, according to the author, be further illustrated by placing, at the bottom of a beaker filled with petroleum or vaseline oil, a metallic disc carrying a layer of brass turnings, surmounted by a small metallic sphere connected with a feeble influence machine. The first phenomenon observed is the "electric dance" of the particles discharging the electric charge by convection. On diminishing the distance between the disc and the sphere, a moment arrives at which a number of particles form themselves into a chain, and a spark proceeds along the chain, welding it together, while all the loose particles fall back on to the disc. It is clear that the rate of oxidation of a metal has less influence upon the behaviour of the chain than has its fusibility. The dimensions of the particles will also have an important influence, since upon them depends the chance there is of a chain being formed. E. E. F.

128. *Hertzian Waves and Coherers.* **A. Gilardi.** (Elettricità, Milan, 18. pp. 601–604, September 23, 1899.)—Complete interference is not secured by Drude's methods, and the series of interference phenomena is irregular. The coherer is not a suitable instrument for exploring maxima and minima. A. D.

129. *Vacuum Tubes as Wave Detectors.* **A. Righi.** (N. Cimento, 8. 4. pp. 44–49, 1898.)—The author has designed a vacuum tube showing a continuous streak of light between the two electrodes, which under the influence of electric waves breaks up into the usual succession of positive strata, dark space, and kathode light. The original appearance is restored when the waves cease. The breaking up is accompanied by a lowering of the resistance. The author does not give details of the construction of the tube. E. E. F.

130. *Opacity.* **O. Lodge.** (Phys. Soc., Proc. 16. pp. 343–386, 1899. Presidential address to the Physical Society.)—In this address the author discusses opacity from the point of view of the electromagnetic theory of light. By experiments in inductive telegraphy, the question was suggested how far

intervening layers of moderately conducting matter were able to act as a screen preventing the induction sought. The treatment has reference to Maxwell's Electricity and Magnetism (Chapter 20), where for cases of high conductivity he gives the equation $\frac{d^2F}{dx^2}=\frac{4\pi\mu}{\sigma}\frac{dF}{dt}$.

Here F may be any vector representing the amplitude of the disturbance, and σ is the electrical resistance of the medium. The formal solution is—

$$F=\varepsilon^{-Qx+ipt}$$

or—

$$F=\varepsilon^{-\left(\frac{2\pi\mu p}{\sigma}\right)^{\frac{1}{2}}x}\cos\left\{pt-\left(\frac{2\pi\mu p}{\sigma}\right)^{\frac{1}{2}}x\right\}$$

giving a distorted wave, different wave-lengths travelling with different velocities—known as the diffusion-case.

The author compares this with Fourier's equation of conduction of heat,

$$\frac{d^2\theta}{dx^2}=\frac{c\rho}{k}\frac{d\theta}{dt},$$

in which $c\rho$ is capacity for heat and k is heat conductivity. It is pointed out that heat conductivity and electric conductivity play opposite parts in the two cases, and this can only be explained by calling in ether as the universal solvent.

Reference is then made to Whitehead's paper (Phys. Soc. Proc. June, 1897), which was supposed to support the conclusion that the failure to obtain results in some trials of induction signalling at the Goodwin Sands was due to the conductivity of the water mopping up, so to speak, the induced currents. The author quotes and gives *in extenso* a paper of Heaviside's on this question; also he suggests another explanation of his own.

Maxwell's equation for cases where the conductivity of the medium is relatively small is—

$$\frac{d^2F}{dx^2}=\mu K\frac{d^2F}{dt^2}+\frac{4\pi\mu}{\sigma}\frac{dF}{dt},$$

which leads to a solution of the same form as (1), namely, $F=\varepsilon^{-Qx+ipt}$, but with a different value of Q.

Maxwell's treatment of this equation is discussed and compared with Heaviside's. For luminous frequency and bad conductors the solution takes the form—

$$F=F_0\varepsilon^{-\frac{2\pi\mu v}{\sigma}x}\cos p\left(t-\frac{x}{v}\right),$$

which is the equation applied by Maxwell to calculations of opacity.

The other extreme case, diffusion, is compared with the transmission of slow signals by submarine cables. Dr. Lodge then introduces Heaviside's at present unverified theory of magnetic conductance, and considers its probable effects. Finally two other kinds of opacity are considered, namely, one not connected with conductivity but due to variation of the constants, K, μ. This is an affair of boundaries. Secondly, opacity like (says the author) that of lamp-black, in which the molecules appear to take up energy directly and convert it into their own motion. The author accepts the theory of Heaviside that a current along a wire is to be regarded as the transmission of a wave in the space surrounding the wire. The opacity of gold leaf is discussed and a method pointed out by which some part of the discrepancy between theory and observation may be removed. Attention is called to a new theory of Heaviside's concerning the reflection of light at the two surfaces of a thin film, and this is discussed with reference to the theories of Drude, J. J. Thomson, and others. Heaviside's notes on electrical waves in sea-water is given in full in the appendix. S. H. B.

131. *Alternate Current Arcs.* (Instit. Elect. Engin., Journ. 28. pp. 455–474, August, 1899.)—This is a discussion on Duddell and Marchant's paper (see 1899, Abstract No. 829).

L. Andrews showed some diagrams from a photographic record of the current curves from two alternators in parallel and the E.M.F. curve from a transformer excited off the 'bus bars.

J. A. Fleming referred to the unidirectional arc between a metal and carbon, and mentioned the close analogy of the experiments he made in 1890. In these, when a single cell and galvanometer were connected between a middle insulated plate and the negative terminal of a glow-lamp, the current could only flow across the vacuous space when the negative pole of the cell was in connection with the hot carbon. He thought that if in the unilateral zinc-carbon arc the metal pole were heated with an oxyhydrogen flame, the arc would no longer be unilateral. With regard to the electrolytic theory of the arc, he assumes that carbon molecules are broken up into ions which are drawn in the opposite direction by the electric force; if they are monatomic metals this process cannot go on. Another thing he found was that there is a distinct lag between the light-curve of the alternating arc and the current; they are not in step with one another.

S. P. Thompson remarked that in the alternating current arc the current does not entirely keep step with the voltage, and asked whether this is due to the arc acting as a self-induction to produce a lag or as a capacity to produce a lead; but by referring to Duddell's diagram he found that there is no lag in a great many cases, that the potential difference-curve starts and ends at absolutely the same place as the current-curve, and yet the arc acts so that in some way or other it is out of phase; so he finally came to the conclusion that both effects in fact occur.

Duddell and **Marchant,** in their reply, said that they attempted to force the current to flow in both directions through the steady metal-carbon arc by increasing the self-induction in series with it and the E.M.F. of the alternator until the instantaneous value of the P.D. tending to force the current from carbon to metal rose to between 500 and 600 volts, but without success. Heating the metal electrode did not destroy the unilateral nature of the arc. While cooling the carbon they found that the maximum instantaneous value of the current was slightly larger when it flowed from the solid carbon to the cooled carbon than when it flowed in the opposite direction. In each experiment they were obliged to regulate the arc length to allow for the consumption of the carbons, but, as long as the conditions of the dynamo and circuit remained the same, it was found that regulation of the arc length so as to keep the P.D. between its terminals constant resulted in constant arc length, as well as constant current and power supplied to the arc. They finally state that the oscillograph, having a periodic time of $\frac{1}{5000}$ to $\frac{1}{10000}$ of a second, can easily be used to record high-speed telegraphic currents if as large as 30 or 40 milliamperes, but cannot be used for telephonic currents, as it is not yet sensitive enough. E. C. R.

132. *Exact Capacity of Submarine Cables.* **J. E. Young.** (Instit. Elect. Engin., Journ. 28. pp. 475–489. Discussion pp. 489–508, August, 1899.)—The author discusses the difficulties arising from (1) The insufficient definition of the quantity sought for, which is a function of the time of charge; (2) The difference of rates of absorption of cables and standard condensers; (3) The variation of absorption of both cables and condensers with time and with temperature; and (4) Leakage errors.

A modification of the Thomson test is described. In this both leakage and absorption are balanced by observation and adjustment during charging, absorption in this case being treated as apparent improvement of dielectric resistance, *i.e.*, the condensers are shunted by a resistance which is adjusted till it approximately balances the apparent dielectric resistance of the cable at any time of charge. Thirty seconds is given as a standard time of charge when testing conductor resistance and inductive capacity. In the discussion **W. J. Murphy** remarked that a connection should be established between the sliding index and the point of junction of the condenser and cable; this prevents the condenser taking up the full potential of the battery while the cable potential is being reduced. Another way is to put a resistance across the condenser inversely proportional to the capacities of condenser and cable and to the dielectric resistance of the latter. Temperature does not affect "free charge" capacity. **A. Siemens** claimed that the speed of the Commercial cable of 1894 is superior to that of the Anglo-American by the reduced sponginess or absorptive quality of the dielectric. **C. Bright** wished to have some assurance that speeds are compared when the definiteness of the signals is the same, or with a standard set of instruments and a standard type of signals. He preferred testing a cable for continuity, by capacity measurements to a sealed end. **Taylor**: The practice of calculating the speed of any given cable on the basis of an empirical constant derived from actual observed speeds of some other cable is wrong. The longer the cable the better the speed constant. **A. Dearlove**: A standard time of charge should be adopted. Increasing temperature was found to lower the capacity of guttapercha cores by 0·02 per cent. per degree Fahr. **Murphy**: The capacity test should be taken when the curve of electrification of a cable becomes sensibly horizontal. An eleven-strand cable clearly increases the self-induction of the cable, and the Telegraph Construction Company's taped core will do so still more. A standard time is unnecessary. M. O'G.

133. *Dielectric Constant in Solid and Liquid States.* **R. Abegg** and **W. Seitz.** (Zeitschr. Phys. Chem. 29. pp. 491–493, July 28, 1899.)—The object of these experiments was to observe the changes which take place in the value of the dielectric constant of a crystalline solid as it gradually cools in the liquid state and then slowly crystallises.

The solid experimented upon was p-Azoxyanisol. This solid melts at about 95° to a viscous opaque liquid which gradually becomes more transparent as the temperature rises until, at 134°, it is perfectly clear and transparent. The dielectric constant of the liquid above 134° is fairly constant, about 4·0; then, as the temperature falls below 134°, the dielectric constant slowly rises until, at 95°, it is 4·3. At this temperature (at which the crystallisation begins) a great change takes place, the dielectric constant falling very rapidly as the liquid crystallises, until when all is solid at about 80° the constant is 2·3. J. B. H.

134. *Dielectric Constant of Stretched Glass.* **O. M. Corbino.** (Accad. Lincei Atti, 8. pp. 238–244, November 5, 1899.)—In reply to Ercolini's criticism (see 1899, Abstract No. 464), the author maintains that the dielectric constant of glass does not increase under a pulling stress. The interpretation put by Ercolini upon one of his experiments contradicts the fundamental electrostatical law, that if a conductor A possesses a constant charge at a potential V_1, and another conductor B at potential V_2 entirely surrounds the former, the introduction of any dielectric only reduces the potential of A without affecting that of B. E. E. F.

135. *Temperature-coefficient of Dielectric Constants: Change from Liquid to Solid State.* **R. Abegg** and **W. Seitz.** (Zeitschr. Phys. Chem. 29. pp. 242–248, 1899.)—Abegg's formula $\frac{dD}{dT}=-\frac{1}{190}D$ is found by Nernst's method to give good agreement for the liquid alcohols at temperatures as low as −140°, and for nitrobenzene down to −9°, in contradiction to the Clausius-Mossotti and Gladstone formulæ. (See also Ratz, *Zeitschr. Phys. Chem.* 19. p. 94, 1896, and Philip, ibid. 24. p. 18, 1897.) On solidification the dielectric constant drops suddenly and enormously.

The increase of viscosity of the alcohols to a glassy solid, which is to the eye a continuous change, is shown by the dielectric constant to be a sharp change of state, the telephone sound becoming uncompensatable and afterwards giving again a minimum in a widely different position. The *visible change* from glass to crystalline solid takes place *without* change of the dielectric constant. B. B. T.

136. *Electrothermal Relations.* **F. Kohlrausch.** (Preuss. Akad. Wiss. Berlin, S.ber. 38. pp. 711–718, July 27, 1899.)—In a previous paper (Pogg. Ann. 156. 601, 1875) the author considered the thermal equilibrium of an electrically heated cylinder on the assumption that the ratio of the electric to the thermal conductivity is constant; that assumption is not, however, justified by experiment, and the present paper is an attempt to consider the problem on a more general basis.

Let the electric potential at a point x, y, z in a uniform medium be v and the temperature at that point u. Let κ be the electric and λ the thermal conductivity of the medium: these quantities being functions of the temperature only. Then, when the stationary condition is reached, the equilibrium in generation and flow of heat is expressed by—

$$0=\kappa\left[\left(\frac{\partial v}{\partial x}\right)^2+\left(\frac{\partial v}{\partial y}\right)^2+\left(\frac{\partial v}{\partial z}\right)^2\right]+\frac{\partial}{\partial x}\left(\lambda\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(\lambda\frac{\partial u}{\partial y}\right)+\frac{\partial}{\partial z}\left(\lambda\frac{\partial u}{\partial z}\right) \qquad (1)$$

where the potential is subject to the condition—

$$\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}=-\frac{1}{\kappa}\left(\frac{\partial\kappa}{\partial x}\frac{\partial v}{\partial x}+\frac{\partial\kappa}{\partial y}\frac{\partial v}{\partial y}+\frac{\partial\kappa}{\partial z}\frac{\partial v}{\partial z}\right) \qquad (2)$$

(depending on Ohm's law); but as κ and λ depend on the temperature only, we may write the total differential coefficients—

$$\frac{d\kappa}{du}=\kappa' \text{ and } \frac{d\lambda}{du}=\lambda'$$

and get—

$$\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}=-\frac{\kappa'}{\kappa}\left(\frac{\partial u}{\partial x}\frac{\partial v}{\partial x}+\frac{\partial u}{\partial y}\frac{\partial v}{\partial y}+\frac{\partial u}{\partial z}\frac{\partial v}{\partial z}\right) \qquad (2a)$$

First consider the case of a cylindrical conductor whose end faces are (different) equipotential surfaces, and whose sides are both electrically and thermally isolated. The solution can then be shown to *depend neither on* κ *nor on* λ, *but only on the ratio* κ/λ. It is—

$$u=-\frac{1}{2}\frac{\kappa}{\lambda}v^2+\mathrm{A}v+\mathrm{A}',$$

where A and A′ are constants. Hence by determining the temperatures and potentials at three points A and A′ can be eliminated, and the ratio of conductivities found. This is proposed as a method of measuring the thermal conductivity of a bar in terms of the easily measured electric conductivity, and has been carried out by Jaeger and Diesselhorst (see following Abstract), using such small differences of temperature that κ/λ may be regarded as constant.

Next, if the conductor is of any shape, but is thermally and electrically isolated at all points of its surface except two areas through which the current is supplied, and are consequently two (different) equipotential surfaces, it may be shown that the same solution holds. Hence, if the bar experimented on be not exactly cylindrical and be interrupted by holes in which to place thermocouples and so on, the method will still be exact, provided the temperature and potential be measured at precisely the same point, and that the loss of heat by radiation may be neglected.

It is obvious that the temperature reached by the bar under the above conditions will be the highest to which it can be raised by the given electromotive force. If the ends of the bar are at the same temperature the middle point will be hotter by—

$$\frac{1}{8}\frac{(v_1-v_2)^2}{\sigma}$$

where v_1 v_2 are the potentials of the ends and σ is the mean value of κ/λ. The lowest value of κ/λ is about $6{\cdot}4\times10^{-6}$ volts/degree. Hence 0·01 volt potential difference will raise the centre of the bar by 2°.

In considering large differences of temperature we must make an assumption as to the dependence of κ/λ on u. Assuming, with Lorenz, that it is inversely proportional to the absolute temperature, we find that 0·1 volt would give 168° rise of temperature, 1 volt 3,140°. R. A. L.

137. *Conductivity for Heat and Electricity, Heat-Capacity and Thermo-electric Power of Certain Metals.* **W. Jaeger** and **H. Diesselhorst.** (Preuss. Akad. Wiss. Berlin, S.ber. 38. pp. 719–726, July 27, 1899.)—The ratio of the heat conductivity λ to the electric conductivity κ is here investigated, for pure Zn, Sn, Pb, Cu, Cd, Bi, Ni, Al, Ag, Fe, Pt, Pd, Au, and for a steel, cast iron and constantan ($\frac{2}{5}$ Ni, $\frac{3}{5}$ Cu), by Kohlrausch's method wherein the temperatures V_1, V_2, V_3 and electric potentials v_1, v_2, v_3 at three points of a homogeneous conductor are determined when an electric current is passing through it and the temperatures have become stationary, the theory giving—

$$\frac{\kappa}{\lambda}=\frac{V_1(v_2-v_3)+V_2(v_3-v_1)+V_3(v_1-v_2)}{\frac{1}{2}(v_2-v_3)(v_3-v_1)(v_1-v_2)}$$

if there is no loss of heat by external conduction. The substances were taken in the form of cylindrical bars with their ends fastened to thick copper blocks which were screwed into large water baths; the rods were placed axially within a double-walled cylindrical jacket of copper filled with wadding and with water or steam passing between the walls, and the temperatures were measured thermo-electrically. For details the memoir, which is a communication from the Phys.-Tech. Reichsanstalt, must be referred to. For the pure metals named λ/κ at 18° C. ranges from 0·00000636 for Al to 0·00000962 for Bi, and at 100° from 0·00000844 for Al to 0·00001077 for Bi. The heat capacity and thermo-electric powers were also obtained from the experiments.

R. E. B.

138. *Thermoelectric Theory.* **W. Voigt.** (Wied. Ann. 69. 3. pp. 706–717, November, 1899.)—The author raises some grave objections to Liebenow's theory of thermo-electric and electrothermal phenomena.

The equation—

$$S^2 = \frac{L}{\lambda T}\left(\frac{dT}{ds}\right)^2$$

where L and λ are the thermal and electric conductivities, S the E.M.F., T the temperature, and s the length of the cylinder, is not only faultily derived, but its form shows that the quantity but not the direction of the E.M.F. is indicated. The apparent agreement of Liebenow's theory with observation is no confirmation, since in his practical applications no recourse is had to the novel methods introduced.

E. E. F.

139. *Peltier Effect in a Magnetic Field.* **A. Pochettino.** (Accad. Lincei Atti, 8. pp. 50–57, July 16, 1899.)—In an iron copper couple, the the value of the coefficient of the Peltier effect varies with longitudinal magnetisation, first increasing to a maximum value of 0·008968 in a field of 98 c.g.s. units, then decreasing and passing through its normal value at a field-strength of about 345 units, results which are in accord with Houllevigue's formulæ (Ann. de Chim. et de Phys. (7) vii. p. 495, 1896). The formula derived from Houllevigue's experiments by means of the Thomson equation connecting the Peltier effect with the thermo-electric power between two metals is found to represent the facts only at a field-strength of 700 units. The variations in the Peltier effect are independent of the direction of the magnetisation, so that the magnetising current may be reversed without affecting the result.

A. D.

140. *Investigation of the Microphone.* **J. Cauro.** (Écl. Électr. 19. pp. 295–302, 333–337, and pp. 410–416, 1899.)—A study of the current variations in primary and secondary circuits of the E.M.F. on open and closed circuit, of the energy spent in a telephone, and of the magnitude of the movements of the diaphragm. The instruments selected are described. Alternating potentials were measured by a Curie electrometer (with flat mirror and giving virtual images) used only as an electroscope. Alternate currents were taken by a modified electro-dynamometer by Giltay-Bellati with soft iron needle, used only as a zero instrument. A spiral strip oscillograph which, however, required standardising with an electrometer for each frequency, was used and the movements of the strip in a strong field noted with a microscope. A telephonic relay having only the self-induction capacity and resistance of a short straight wire was made on the basis of the oscillograph. There is practically no limit to the number of such instruments which might be placed on one line without destroying distinctness.

The source of sound was a pipe whose lip was vibrated electrically to avoid any movement of translation of the air. Sound intensity was measured by observing with a microscope the movements of a rubber membrane, and incidentally it is proved that the movements of the membrane are due to the air only. The displacements of microphone and receiver diaphragms were measured by fixing a glass disc to the membranes and utilising Newton's rings, the displacements being suitably slowed down by Lippmann's stroboscope which is explained and illustrated.

Speech consists of a series of musical vowels separated by stoppages (the consonants), which give rise to extra currents more easily audible than the pure musical notes. All measurements were made after the musical note had been established. When the electrometer method was used for current measurement a resistance without self-induction or capacity (see Comptes Rendus, cvii. p. 779, 1889; cxx. p. 308, 1895) was necessary, and the potential difference at the ends of a known resistance gave the effective current. The table of results cannot be abstracted, but the following is an example: With a distance of the pipe from the microphone of 175 mm. through 20 km. of cable with the loudest note which did not produce cracking sounds, the mean receiver voltage was 2·38, the effective voltage was 2·46, the microphone terminal volts were 1·35 mean and 1·28 effective; the current through the microphone at rest was 0·078 amps., the mean current variation was 0·08 and the effective current variation was 0·28 of the microphone current when at rest. It was found that the effective variable current is independent of the pitch, is proportional to the amplitude of vibration of the sound and is about a quarter of the steady current which continues unchanged during transmission. The effective E.M.F. on open circuit varies as the amplitude of sound and inversely as the pitch. Sound is still audible with one-millionth of an ampere in the secondary and this current does not appear to vary with the pitch (ω). It will be seen that various notes are not affected differently by the telephone, and therefore that timbre should not be lost in transmission. This depends on the importance of the self-induction (L) of the usual apparatus whose apparent resistance is $\sqrt{R^2+L^2\omega^2}$, namely, at 600 periods R^2 is about 10^6, whereas $L^2\omega^2$ is about 50×10^6. On a long distance line like Paris-Marseilles the apparent self-induction of both line and insulation is a few hundredths of a henry so that R^2 is of the order 10^6 and $L^2\omega^2$ is 2×10^3. Hence, as far as distortion of sound is concerned, the line acts as a resistance which is not as important as the apparent resistance of the apparatus: the latter depends mainly on the pitch and the self-induction. M. O'G.

141. *Photoelectric Phenomena.* **E. R. v. Schweidler.** (Akad. Wiss. Wien., S.ber. 108. pp. 273–279, 1899.)—According to Stoletow and Branby the photoelectric current increases with increasing potential difference, but more slowly than the latter, and appears to approach an upper limit. On the other hand, Elster and Geitel found a potassium cell behave in just the opposite way; the current increased much more rapidly than the potential difference of the electrodes. Kreusler also found that the photoelectric current increases with very great rapidity in the neighbourhood of the discharge-potential (*i.e.*, the potential at which spark-discharge begins).

The author's experiments confirm Kreusler's results. Although the galvanometer readings are irregular, they show clearly that from a given point onwards the current increases more rapidly than the potential difference of the electrodes. At low pressures this behaviour begins at potentials which are relatively small (compared with the discharge-potential); at atmospheric pressure it only begins in the neighbourhood of the discharge-potential, and is then very rapid. D. E. J.

142. *Measurement of Variable Discharges.* **C. Heinke.** (Wied. Ann. 69. 3. pp. 612–625, November, 1899.)—In addition to the stationary continuous-current discharge and the symmetrical alternate current, attention has recently

been directed to the periodically varying discharge produced from continuous currents by the interposition of an interrupter. An elucidation of the detailed process of discharge in this case is very desirable on account of the characteristic relations existing between the current and potential on the one hand and the effective expenditure of energy on the other. The existing measuring instruments and methods are inadequate for dealing with such measurements, as has been shown by the many obscurities still attaching to the action of the Wehnelt interrupter. Instruments containing iron do not give indications independent of the frequency, while those free from iron, like most dynamometers and hot-wire instruments, usually are governed by the square of the quantity to be measured. The author points out that satisfactory results may be arrived at by measuring potential and current simultaneously with galvanometric and "efficiency" instruments, thus splitting them up into a constant term and a periodically variable term. The latter may be replaced by an equivalent sine wave. The total work of the "wave-current" is best measured calorimetrically, by converting the whole energy expended into heat.

E. E. F.

143. *Conductivity, Viscosity, and Pressure.* **G. Tammann.** (Wied. Ann. 69. 4. pp. 767–780, December, 1899.)—The influence of pressure up to 4,000 atmospheres upon conductivity and viscosity was observed in the case of decinormal solutions of sodium chloride and acetic acid respectively. The almost completely ionised chloride solution shows a very different behaviour from the unionised acid. The conductivity increases slowly with the pressure, but passes through a maximum at 2,500 atmospheres, after which it diminishes again. The resistance never descends below 91 per cent. of the original resistance. In the acetic acid solution the resistance decreases continuously and considerably, reaching less than half its original value at 2,500 atmospheres. In the case of the chloride solution, which is nearly completely dissociated, no further pressure can produce much additional dissociation. Hence, by subtracting the change of volume of the solution from the change of resistance under pressure, we obtain practically the change of ionic friction under pressure. The author finds that the curves of ionic friction are the same as the curves of viscosity. E. E. F.

144. *Graphical Treatment of Induction Motor Problems.* **W. Baxter, Jr.** (Elect. World and Engineer, 34. pp. 490–494, September 30, 1899.)—By means of polar diagrams the author explains the various actions taking place in an induction motor. A. H.

145. *Power in Circuits Supplied with Distorted E.M.F. Waves.* **S. J. Barnett.** (Elect. World and Engineer, 34. p. 305, August 26, 1899.)—Each simple harmonic term in the Fourier series representing the E.M.F. wave produces its own wave of current. The total mean power in the circuit is equal to the sum of the powers corresponding to the various harmonic components of the wave, each of which develops an amount of power which is not in any way influenced by the presence of the other harmonics. A. H.

146. *Determination of Ratio of Transformation.* **J. R. Bibbins.** (Elect. World and Engineer, 34. p. 376, September 9, 1899.)—The method described is useful when only a single voltmeter, the range of whose readings corresponds to the higher of the two voltages, is available. In such cases the instrument would generally be incapable of reading the lower voltage with

any degree of accuracy. The higher P.D. is read first, and then one terminal of the primary winding is joined to one terminal of the secondary, and a reading obtained when the voltmeter is across both windings. The difference between the two readings, divided by the first reading, gives the required ratio of transformation. A. H.

147. *Effect of Pressure on Resistance of Metals.* **S. Lussana.** (N. Cimento, 10. pp. 73–84, August, 1899.)—After referring to the works of former experimenters, the author describes his own researches on the resistance of various metals and alloys when immersed in oil and subjected to pressures up to 1,000 atmospheres. Wires of iron, silver, nickel, lead, copper, platinum, and several alloys were employed, and tables are given showing the resistance of each at various increasing and decreasing pressures. With increasing pressure the resistance diminishes, tending to a minimum value at very high pressures. If sufficient time elapse between the compression and the measurement of the resistance—usually an hour—the curves taken with increasing and diminishing pressures are practically coincident. As in the case of the temperature variation, the coefficient is much smaller for the alloys than for the pure metals. At atmospheric pressures the actual values are: for iron, 38×10^{-7}; copper, 31×10^{-7}; platinum, 24×10^{-7}; lead, 194×10^{-7}; while for manganin, $5{\cdot}6 \times 10^{-7}$; and for brass, $4{\cdot}3 \times 10^{-7}$, per atmosphere of pressure. From a comparison of these with the temperature and volume coefficients the author concludes that the specific resistance of a metal depends not only on the proximity of the molecules, but also on their velocity of vibration.

In addition to the permanent variation of the resistance with altered pressure, a much larger temporary variation was observed, the duration of which depended on the duration of the previous condition of the conductor. When a platinum wire was subjected to a pressure of 500 atmospheres for an hour, and the pressure suddenly removed, the resistance rose to 0·14 per cent. above its normal value, and gradually fell till in forty-five minutes it had assumed a steady condition. If the previous state of the conductor has been of long duration the temporary variation following the change of pressure assumes the form of a very slow and strongly damped oscillation above and below the normal resistance. In the case of a platinum wire which had been subjected to a pressure of 500 atmospheres for twenty-four hours the resistance took three days after the pressure was removed to assume a steady value, executing in that time three oscillations with amplitudes of 0·3 per cent., 0·013 per cent., and 0·006 per cent. of the normal value. L. B.

148. *Control of Sheet-Iron Tests.* **J. Epstein.** (Elektrotechn. Ztschr. 20. p. 590, August 17, 1899.—Report read before the Deutscher Elektrotechniker in Hanover.)—The author urges the importance of establishing standard methods of testing sheet iron for various purposes. (See 1899, Abstract No. 1,572.) A. H.

149. *Piezo-Electricity.* **F. Nachtikal.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 1. pp. 109–118, 1899.)—This paper treats of the proportionality between piezoelectric charges and the pressures producing them. The author placed the crystals between two copper plates insulated by ebonite, and piled weights on to a scale attached to the upper plate. The ends of the crystals were covered with tinfoil, and were connected with an electrometer and the earth respectively. The results show that the deviations

from proportionality between the piezoelectric moments and the pressures are quite small. At the higher pressures, quartz shows a deficiency of piezo-electricity charge, while tourmaline shows a slight excess over the expected value. E. E. F.

150. *Wire-resistance Paradox.* **P. Girault.** (Ind. Élect. 8. pp. 413–414, September 25, 1899.)—Consider two metals, having similar physical constants, except as regards resistivity, and let there be two wires made, one from each of the metals, and let the wires be of unequal lengths and diameters, but of equal resistance. The author writes down the equation for the (equal) heat generated in each wire, using the ordinary C^2R formula, R on each side of the equation being expressed in terms of the lengths, diameters, and resistivities. He then substitutes the respective volumes in those expressions. It is thus shown that the diameters and volumes vary directly as the cube roots of the resistivities, and inversely as the diameters of the wires. Hence it appears that by employing a metal of less resistivity a resistance wire may be made of less volume. This "paradox" is explained by the consideration that the volume is in practice determined by the cooling surface—*i.e.*, by the heat lost, and not alone by the heat generated. R. A.

151. *Resistance of Amalgams.* **R. S. Willows.** (Phil. Mag. 48. pp. 433–456, November, 1899.)—The variations of the electric resistance of amalgams of zinc, cadmium, tin, and magnesium with temperature are here experimentally investigated. The results are given in the form of curves, some of which have very peculiar forms, the curve for falling temperature being in some cases quite different from that for rising temperature. This is particularly the case with the zinc amalgams, in which at certain temperatures (depending on the percentage composition of the amalgam) very sharp bends occur in the curves, indicating some rapid changes in the chemical structure of the amalgam. In some of the amalgams these bends occur only where a change of state takes place, but in others they occur where no external change is apparent.

The variations of other physical properties of the amalgams with temperature are also experimentally determined, and, in the case of a zinc amalgam, the time curve of absorption and emission of heat under definite conditions shows steady parts corresponding to the angular bends in the resistance curve.

The author considers also what theoretical structure of the amalgam would give the observed results, and obtains one analogous to that which Guillaume supposes to exist in nickel steel in order to explain its peculiar physical properties. J. B. H.

152. *Absolute Determination of the Kilohm.* **A. Guillet.** (Journ. de Physique, 8. pp. 471–477, September, 1899.)—The method of determination is analogous to that due to Lippmann. A Thomson galvanometer is wound differentially. One of the pairs of coils, of resistance G_2 receives per second n discharges of the value q, and the other pair of coils of resistance G_1 a compensating current of intensity i. When a balance is obtained the relation—

$$nq = i$$

is satisfied.

Induction being produced in a circuit of resistance r, between two coils

B, *b* of mutual induction M, by the make or break of a current I, we have—

$$q = \frac{MI}{r}$$

Also $I = \frac{V}{R}$ where V is the potential difference between the ends of the resistance R carrying the current I. The compensating circuit is formed by a resistance R, and a variable resistance S as a shunt to the windings G_1, so that putting—

$$R' = R + \frac{S\,G_1}{S + G_1}$$

we get—

$$i = \frac{S}{S + G_1} \cdot \frac{V}{R}$$

and obtain the equation—

$$\frac{nM}{rR} = \frac{S}{S + G_1} \cdot \frac{1}{R'}$$

whence—

$$R = nM\left(1 + \frac{G_1}{S}\right) \cdot \frac{R'}{r} \qquad (1)$$

The coils G_1 and G_2, traversed by the same current, do not generally have equal effects on the galvanometer needles, so that equation (1) requires modification. Suppose that—

$$R = pnM\left(1 + \frac{G_1}{S}\right) \cdot \frac{R'}{r} \qquad (2)$$

where the value of p depends upon the relative positions of the coils and the needles.

Now interchange the coils G_1 and G_2, and again adjust to equilibrium, obtaining an equation—

$$R = \frac{1}{p} \cdot n'M\left(1 + \frac{G_2}{S_1}\right) \frac{R_1'}{r_1} \qquad (3)$$

On multiplying (2) and (3) and putting—

$$\gamma_1 = \frac{G_1}{S}\ ;\ \gamma_2 = \frac{G_2}{S}\ ;\ \lambda = \frac{R'}{r}\ ;\ \lambda_1 = \frac{R_1'}{r},$$

we get—

$$R = M\sqrt{nn'\,(1 + \gamma_1)\,(1 + \gamma_2)\,\lambda\lambda_1}.$$

Another correction has yet to be applied. When the inductive circuit is broken the difference of potential V takes a new value V_1. Consequently the compensating current is not constant, it varies very little on account of the small resistance of the battery used.

Let f be the time during which the inductive and compensating circuits are simultaneously active, and let $b = \frac{V_1}{V}$; we can then proceed as if the compensating circuit were subjected to a constant potential difference—

$$e = \left\{ f + b\,(1 - f) \right\} V = \frac{1}{\phi}\,V \text{ (say).}$$

R is then finally calculated from the formula—

$$R = M\sqrt{nn'\,(1 + \gamma_1)\,(1 + \gamma_2)\,\lambda\lambda_1 \,.\, \phi}.$$

Working on this formula, in which M is wound so as to be easily calculable, the author arrives at 106·2 centimetres of mercury as the value of the ohm.

W. G. R.

153. *Absolute Determination of the Kilohm.* **A. Guillet.** (Écl. Électr. 20. pp. 161–171, August 5; pp. 212–218, August 12; pp. 288–291, August 26; pp. 328–336, September 2; pp. 376–380, September 9, 1899. See also preceding Abstract.)—In this series of articles the author gives a complete historical summary of the methods adopted in the direct absolute determination of the kilohm, paying particular attention to Lippmann's method, upon which his own method is based. W. G. R.

154. *Measurement of Internal Resistance of Accumulators.* **E. C. Rimington.** (Elect. Rev. 45. pp. 623–624, October 20, 1899.)—A variety of ways are described, all based on a comparison of the potential difference of two similar cells, the one discharging, the other on open circuit or practically so. It is worked out as a condenser, as a differential galvanometer, and as a Wheatstone bridge method; and modifications of the latter are given by means of which errors due to polarisation may be eliminated.

E. J. W.

155. *Current Strength in Three-pointed Star Systems.* **A. E. Kennelly.** (Elect. World and Engineer, 34. pp. 268–270, August 19, 1899.)—The current strengths in three-pointed star resistance systems are calculated by the method of vectors. The results arrived at are—

$$i_1 r_1 = \frac{e_3 r_1 r_3 - e_2 r_1 r_2}{r_1 r_2 + r_2 r_3 + r_3 r_1},$$

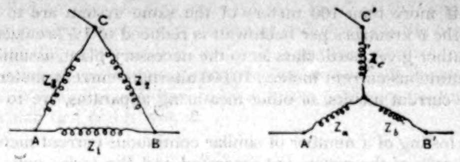
$$i_2 r_2 = \frac{e_1 r_1 r_2 - e_3 r_2 r_3}{r_1 r_2 + r_2 r_3 + r_3 r_1},$$

$$i_3 r_3 = \frac{e_2 r_2 r_3 - e_1 r_1 r_2}{r_1 r_2 + r_2 r_3 + r_3 r_1},$$

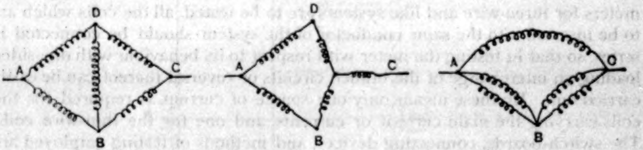
where e_1, e_2, e_3 are the E.M.Fs. between the respective pairs of terminals, r_1, r_2, r_3 the impedances of the three circuits and i_1, i_2, i_3 the currents flowing in them. W. G. R.

156. *Equivalence of Triangles and Stars in Conducting Networks.* **A. E. Kennelly.** (Elect. World and Engineer, 34. pp. 413–414, September 16, 1899.)—Calculations relating to conducting networks may be frequently simplified by replacing a delta or triangle grouping of conductors between any three points by a star or Y-grouping, or *vice versâ*. As an example of the simplicity which may result from such a substitution, the author considers the case of the Wheatstone's bridge, fig. 3. The calculation of the impedance between the points A and C when the bridge is unbalanced is a complex problem. But if we replace the △ B C D by its equivalent Y, as in fig. 4; or if we replace the Y consisting of DA, DB, and DC by its equivalent △, as in fig. 5, then the problem is greatly simplified. The following are the laws according to which such substitutions have to be effected: (1) The impedance of a Y-branch lying between, or replacing, a pair of delta-sides is equal to the product of the impedances of those sides, divided by the impedance of the △ considered as a simple closed circuit. Thus, if figs. 1 and 2 denote equivalent

arrangements, then $Z_c = Z_1Z_3/(Z_1 + Z_2 + Z_3)$, and so on. (2) The admittance of a delta-side corresponding to, or replacing, any two Y-branches is equal to the product of the admittances of those branches, divided by the sum of the admittances of all three branches. If the three conductors contain E.M.Fs., then in replacing a Δ by its equivalent Y the equivalent E.M.Fs. in the Y-branches are determined as follows: Draw the vector E.M.F. diagram of the Δ, and apply at its corners imaginary masses equal to the admittances of the corresponding Y-branches. Find the centre of gravity of the loaded Δ, and connect it with the corners by straight lines. These lines represent respectively the E.M.Fs. to be inserted in the branches of the Y. Some numerical examples are worked out in illustration of the method. A. H.



FIGS. 1 AND 2.—STANDARD TRIANGLE AND "Y."



FIGS. 3, 4 AND 5.—TRANSFORMATIONS OF WHEATSTONE BRIDGE.

157. *Three-voltmeter Method of Power Measurement.* **F. Niethammer.** (Elektrotechn. Ztschr. 20. pp. 701–703, October 5, 1899.)—An elaborate criticism of the three-voltmeter method. The author arrives at the conclusion that from every point of view the wattmeter method is superior to the three-voltmeter one, and that there is no longer any justification for the use of the latter method. A. H.

158. *Loop Test on Electric Light Cables.* **J. Wright.** (Elect. Engin. 24. pp. 295–296, September 8, 1899.)—The author uses the Post Office bridge; shows how to adapt a rough slide wire to it of 20-gauge copper, and how to connect the cable when there is an E.M.F. in the fault, as well as other practical details. M. O'G.

159. *Testing Electric Meters and Instruments.* **J. Sahulka.** (Zeitschr. Elektrotechn., Wien. 17. pp. 481–486, September 17th; pp. 491–497, September 24th; pp. 515–518, October 8; and pp. 527–529, October 15, 1899.)—In these articles there is described the establishment of laboratories for the official testing of electric meters, measuring instruments, and small motors by the k.k. Normal-Aichungs-Commission of the Austrian Ministry of Commerce, this work being carried out by the author. The author first states the various conditions to be fulfilled by meters—*e.g.*, that they shall not register when no current is passing;

that they shall begin to register with 2 per cent. of their maximum load; that when calibrated at the maximum current, and at 50 per cent. and 2 per cent. of this maximum, the three values of the meter-constant so obtained shall not vary more than ±4 per cent. of the mean of the three values, this mean value being the one given in the certificate. In Austria the present charge for testing is 1 gulden; in addition 3 kreutzers per hectowatt maximum load is charged for each meter, no difference being made between 1 and 100 meters. If more than 100 meters of the same system are to be calibrated at a time the 3 kreutzers per hectowatt is reduced to 1·5 kreutzers.

The author gives particulars as to the necessary plant, assuming that about 30,000 continuous-current meters, 10,000 alternate-current meters, and 10,000 polyphase-current meters, or other measuring apparatus, are to be calibrated annually.

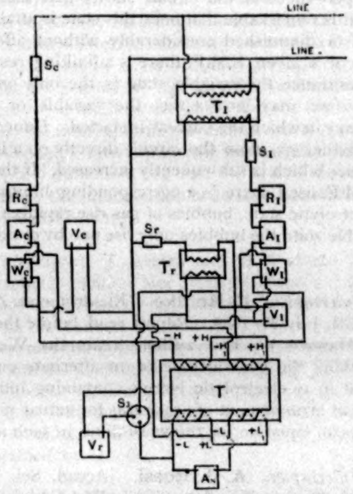
In the testing of a number of similar continuous-current meters, the series and shunt coils of the meters are separated and the series coils put in series with each other, and with a low-voltage battery (*e.g.*, 10 cells capable of yielding 1,000 amperes arranged in series), whilst the shunt coils are put in parallel with each other and connected with a battery of the desired E.M.F. When meters for three-wire and like systems are to be tested, all the coils which are to be inserted into the same conductor of the system should be connected in series, so that in testing the meter with respect to its behaviour with one-sided loading an interchange of the branch circuits or reversal thereof can be easily carried out. By these means only one source of current is required for the coils carrying the main current or currents, and one for the thin-wire coils. The switch-boards, connecting devices, and methods of testing employed are described in detail with reference to diagrams. The cost of current for meters for measuring small and medium quantities of energy amounts to 3 kreutzers per meter.

In the testing of alternate-current meters two separate circuits are employed in the same manner as continuous-current meters; one of these circuits carries the main current for the thick-wire coils of the meter, and the other the current for the shunt circuit of the meter. These currents can be obtained by providing the armature of an alternator with a thick and a thin-wire winding which give electromotive forces of the same phase, or the dynamo is provided with a single winding and the two E.M.Fs. required are generated by means of a transformer; examples of these arrangements are described. Alternate-current meters are also to be tested with a difference of phase (up to 60°) between the current and the terminal E.M.F. This difference of phase can be conveniently obtained by introducing a condenser, or a coil having self-induction, into the thin-wire circuit. Details are also given of methods of testing three-phase meters. C. K. F.

160. *Differential Method for Testing a Single Transformer.* **S. E. Johannesen.** (Elect. World and Engineer, 34. pp. 155–157, July 29, 1899.)—This is a method by which a single transformer may be tested under actual working loss conditions with an energy consumption equivalent to the transformer losses alone, and gives directly approximately correct values for iron loss, leakage, copper loss, impedance and regulation.

In the accompanying figure R_1, A_1, W_1, V_1, and R_c, A_c, W_c, V_c, represent respectively resistances, ammeters, wattmeters, and voltmeters for adjusting voltages and currents, and for measuring iron loss and copper loss energy. A_s is an ammeter for measuring low tension current; S_c, S_1, represent respectively switches governing the currents supplying the copper loss and iron loss ; S_r is a switch governing the pressure reducing transformers; S_3 a three-way switch used in connection with the regulation test. T_1 represents a transformer for stepping up the pressure of the current supplying the iron loss energy ; T_r is a pressure reducing transformer used in connection with the iron loss and regulation measurements. T is the transformer under test.

The figure refers to the case where the energy corresponding to all the losses is supplied to one winding only, in this instance the high tension winding. The current supplying the iron loss energy enters the high tension winding through the terminals $+H_1$ and $-H_1$; in other words the iron loss current is supplied across the terminals of one coil or one-half the high tension winding. The pressure must therefore be adjusted to the normal high tension pressure for which that coil is wound.



In this experiment, close switches S_1 and S_r, adjust the pressure by the resistance R_1 with all the instruments in circuit. The idle current or leakage is measured by the ammeter A_1 ; the pressure which is reduced by transformer T_r, by the voltmeter V_1 ; and the iron loss energy by wattmeter W_1.

The current supplying the copper loss energy enters the high-tension winding through parallel terminals —H and H_1. The low-tension winding is short circuited through an ammeter A . In reality the low tension coils are connected in parallel. In test, close the switch S_o and adjust the pressure by the resistance R_e, with all the instruments in circuit. A_o measures the current supplied ; the voltmeter, V , the pressure ; and the wattmeter, W_e, the energy consumed. The watts registered on the wattmeter should correspond to the watts of copper loss measured in the ordinary way ; that is, by short circuiting the low tension winding through an ammeter and supplying pressure to the high tension winding until the full load current passes through the low tension winding.

W. G. R.

161. *Wehnelt Interrupter.* **E. Rothé.** (Comptes Rendus, 129. pp. 675–677, October 30, 1899.)—When the E.M.F. applied to a Wehnelt interrupter is kept constant, while the resistance of the circuit is varied, a curious phenomenon is observed. The E.M.F. used by the author is 113 volts and the variable resistance consists of two copper plates movable in a column of dilute copper sulphate. When the maximum value is given to the resistance the current is comparatively small (about 4 amperes) but remains constant. The apparatus is now in the electrolytic state and does not act as an interrupter; if an induction coil without the usual break is introduced into the circuit there is not the slightest sparking at the ends of the secondary. If the resistance is gradually reduced, the current increases in accordance with Ohm's law; under the above conditions it thus increases to 11·5 amperes. It then suddenly falls to 2·5 amperes. Thus there is a limiting value for the external resistance at which the state suddenly changes. This new state with a weak current is variable. An ampere-meter in the circuit shows that there are variations in the current; but it is remarkable that once this state is attained, the resistance can be increased or diminished considerably without affecting it. For a given interrupter at a given E.M.F. there is a limiting resistance, such that for every lower resistance the variable state is the only one possible. With higher resistances we may have either the variable or the steady state, according to the way in which the current is started. Hence it is not a matter of indifference whether we close the circuit directly on a large resistance or on a small resistance which is subsequently increased. If the E.M.F. is varied, then to each E.M.F. used there is a corresponding limiting resistance. In the steady, or electrolytic state, bubbles of gas rise rapidly from the platinum wire; in the variable state the bubbles only rise one by one and very regularly.
D. E. J.

162. *Wehnelt Interrupter.* **C. Heinke.** (Elektrotechn. Ztschr. 20. pp. 510–513, July 20, 527–531, July 27, 1899. Report read before the Deutscher Elektrotechniker in Hanover.)—The author treats the Wehnelt interrupter mathematically, taking the general case of an alternate current superposed on a direct current in an electrolytic circuit containing inductive resistance. He also describes an arrangement of apparatus for actual measurements. In conclusion he gives an equation for the work done in such a circuit. R. A.

163. *Wehnelt Interrupter.* **A. G. Rossi.** (Accad. Sci. Torino, Mem. 34. pp. 508–514, 1899.)—The use of a glass tube in Wehnelt's original form may be avoided by soldering the platinum wire to a thick copper wire, and covering the electrolyte with a thick layer of oil. The amount of exposure may be regulated by moving the copper wire up and down, taking care, however, to keep the junction in the oil. E. E. F.

164. *Wehnelt Interrupter.* **E. Ruhmer.** (Elektrotechn. Ztschr. 20. pp. 786–787, November 9, 1899.)—Recent theoretical investigations by Simon show that if T is the periodicity, L the self-induction of the circuit, w the resistance of the interrupter, and E the applied volts—

$$T=\frac{3}{2}:\frac{L}{w}+\frac{K_1w}{E_2}+K_2$$

where K_1 K_2 are constants. Simon has further shown that this equation gives results in agreement with experiment; taking cases where w and L are constant, and varying E. If the length of platinum immersed is maintained constant, and the temperature is also kept steady, K_1 K_2, for the same interrupter, do not appreciably alter. The author describes experiments in which E and w kept constant, L being a variable; he shows that the formula for T still holds. R. A.

165. *Mercury Jet Interrupter.* **M. Levy.** (Elektrotechn. Ztschr. 20. pp. 717–718, October 12, 1899.)—The chief advantage of the new interrupter is its great range of adjustment, which not only extends to the number of interruptions per second, but to the fractional value of the interruption in comparison with the closing of the circuit. It consists essentially of a fine jet of mercury forming one contact piece, and a series of teeth cut in a cylindrical surface forming the other contact piece. The cylindrical surface surrounds the jet. Its axis is vertical, and the teeth taper downwards. The jet may be raised or lowered, and thus the ratio of contact to interruption varied between zero and infinity; hence, whatever may be the E.M.F. used, the mean current strength may be brought to the same uniform value. When not in action there is always interruption of the current—a circumstance which is practically very convenient. The ordinary arrangement of the driving mechanism provides for a speed of 300 to 1,000 revolutions per minute, or, since there are twenty-four teeth on the wheel, and the teeth can be separately mounted or omitted, the interruptions per second can be varied from 5 to 400. All the effects of Wehnelt's interrupter can be repeated with the new interrupter. Moreover, any induction coil can be driven direct from the local lighting system without the interposition of resistances, since the mean current strength can be regulated at will. E. E. F.

166. *Vacuum Interrupter.* **J. Elster** and **H. Geitel.** (Wied. Ann. 69. 2. pp. 483–487, October, 1899.)—MacFarlane Moore's "vacuum vibrator," designed to produce an instantaneous interruption, suffers under the drawback that, as soon as the contact point sticks, the current intensity suddenly rises to a high value, and the point melts off and the tube is often destroyed. To avoid this, the authors keep the hammer vibrating by means of a separate electromagnet outside the vacuum tube, actuated by a mercury interrupter of the Roget spiral type. The spiral and the hammer are tuned to unison, but even so the light obtained is somewhat fitful, and less steady, though safer, than the light obtained by Moore. E. E. F.

167. *Oscillographs.* **A. Blondel.** (Ind. Élect. 8. pp. 361–366, August 25, 1899.)—The author continues his account of recent progress in oscillography (see 1899, Abstract No. 1510). The double bifilar oscillograph of W. Duddell is described in detail, with illustrations; the principal improvements consist in the use of flat strips in the place of round wires, of a pulley equalising the tension, and of two magnetic fields. A table of the constants of the instrument mentioned in Abstract No. 829 (1899) is given; the natural frequency of vibration is 2,700 per second, and the resistance of each bifilar 0·53 ohm. The arrangement of the apparatus for recording three curves simultaneously is explained, as well as the device, due to Boys, for concentrating the light reflected from the mirror to the screen by means of a cylindrical lens.

The author then points out that the bifilar carrying a mirror can be considered either as two separate threads vibrating transversely, or a combination subjected to torsional vibrations; and taking the latter view, he gives formulæ which he has established for the frequency and sensibility of bifilars of flat and round wire. From these it is deduced that to increase the frequency the wires must be of square or circular cross-section, and a metal with a low ratio of density to elasticity must be employed; further, to increase the sensibility, the wires must be of light material and as small as possible. These principles were embodied in an experimental oscillograph, which is described in detail, and with which frequencies exceeding 13,000 per second have been obtained, and a sensibility of 0·25 mm. per milliampere at 1 m. distance.

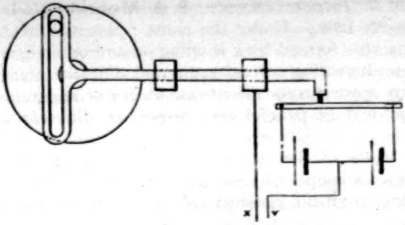
Further refinements of the magnet pole-pieces, to obtain a strong field, are discussed, as applied to an instrument now under construction. The moving rays from the mirrors are received on a revolving mirror; this reflects them upon a ground glass screen and upon a photographic plate, which can be exposed for a suitably short period to obtain a permanent record of the curves. The use of the instrument as a rheograph on Abraham's system is briefly outlined, and the article concludes with a short *résumé* of the best conditions of construction and use of the instruments. A. H. A.

168. *Apparatus for obtaining High Frequencies and Pressures.* **E. Thomson.** (Elect. World and Engineer, 34. pp. 576–578, October 14, 1899. Abstract of paper read before the New York Electrical Society.)—After discussing the various apparatus that have already been devised for obtaining high frequencies and pressures, viz., Rowland's, Tesla's, and Trowbridge's, the author describes his own, which comprises a motor-dynamo, such as is obtained by taking an ordinary continuous-current motor, and tapping the winding so as to obtain alternating currents, *i.e.*, by connecting two of the commutator segments to a pair of insulated rings engaging stationary brushes. The alternating current brushes are connected to the primary winding of a step-up transformer, giving, say, 10,000 to 15,000 volts in the secondary. Driven by the shaft of the machine is a frame of insulating material, having at one side a pair of metal strips, which periodically connect the high potential secondary terminals of the step-up transformer to the + and — foils of a set of condensers in parallel; these connections are made over a small spark-gap, in order to avoid noise and friction. The revolving frame is so adjusted, that the charging contact shall only be made at the tops of the waves, and thus a high potential rendered available for charge. By employing the tops of every third wave only, the condenser foils are always given the same polarity. The revolving frame is also provided with a set of connectors whereby, after the charging strips have been withdrawn from proximity to the stationary contacts connected to the condenser foils, these contacts are connected in series, and the terminals can then discharge over a wide air-gap at high potentials, the length of spark being governed by the number of condenser plates, and the potential of the charging current.

An attachment is also provided, whereby Leyden jar batteries can be charged or a stream of thin sparks obtained. This attachment comprises an insulated revolving connector which consists of a pair of balls connected by a wire and serves to bridge a gap of several inches between the end condenser terminal and an insulated ball, the time of making connection coinciding with the series connection of the revolving frame above referred to. The insulated ball is thus synchronously charged, while the opposite terminal of the apparatus may be put to earth. By changing the connections between the collector rings and the primary of the step-up transformer, the ball may be made either positive or negative as desired. C. K. F.

169. *Production of a Sine E.M.F.* **G. T. Hanchett.** (Amer. Electn. 11. pp. 386–387, August, 1899.)—The author suggests methods of obtaining

E.M.Fs. which are accurately represented by sine curves. In one device, a straight conductor is provided which is of uniform high resistance. The ends of this rod are connected to two or more storage cells in series, care being taken that the number of cells be even, and that each cell has the same E.M.F. and interval resistance. Upon the rod (see fig.) which is thus supplied with current travels a small collecting brush, which is driven by a crank disc and plate in a simple harmonic motion. A lead is brought out at the middle connection of the batteries, and another is connected to the travelling brush. When the machine is set in motion there will exist between these two points an E.M.F. which very approximately follows the sine law.



W. G. R.

170. *Sectorless Wimshurst Machine.* **W. Cotton.** (Electrician, 44. pp. 17–18, October 27, 1899. Abstract from the Bristol Medico-Chirurgical Journal.) —This machine is best described in the words of the original.

"The essential part consists of two parallel circular discs of ordinary window glass, 22 inches in diameter, about ⅛ of an inch thick, and ¼ of an inch apart, varnished with shellac. Being mounted centrally on independent wooden bosses, they can be rotated in opposite directions on a horizontal metallic spindle or axle, which pierces them and is supported at each end by a wooden upright springing vertically from a stout rectangular mahogany base. The lower parts of the two uprights support another horizontal axle parallel to the main one, turned by a handle, with two wooden wheels on it, which by a crossed and an open strap act respectively on the bosses of the glass discs and thus supply the necessary motive power.

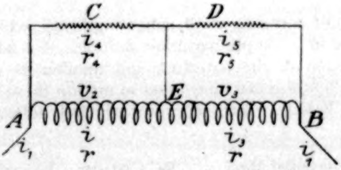
"At each end of the main axle where it projects through the supporting upright is metallically connected a movable brass rod, known as the neutralising rod. The rod is bent round at each end towards the surface of the adjacent glass disc, and has jointed to it at each end a straight piece about 4 inches long, radially disposed as regards the glass disc, parallel to its surface and just within the outer margin thereof. Each straight piece has attached to it at equal distances so as lightly to trail upon the surface of the glass three fine wire brushes. Thus we have two neutralising rods, a near one and a far one, each with two straight pieces, and each straight piece has three brushes, *i.e.*, there are twelve neutralising brushes in all.

"In practice the sectorless Wimshurst is to be preferred to a sectored one of the same size for five reasons: (1) It is easier to construct and keep in order—it is simpler; (2) it never reverses polarity during running—the other does so occasionally; (3) it has a greater output of electrical energy—the tube lights up better with the same amount of mechanical energy expended on the handle; (4) in a sectored Wimshurst, where there is a great resistance in the tube, the inner ends of the sectors leak towards the boss, as shown by a visible brush discharge ; (5) after prolonged use the friction of the brushes on the sectors as they pass leads to the formation of rings of metallic deposit, which break down the insulation."

On the other hand, except under exceptional circumstances, the sectorless Wimshurst is not self-exciting. E. E. F.

171. *Theory of the Potential Divider.* **S. A. Montel.** (Écl. Électr. **20.** pp. 298–302, August 26, 1899.)—Under the name "potential divider" the author denotes an apparatus formed by a winding on an iron core, whose ends are connected across alternating current mains and different points of which are joined to various apparatus for use ; these pieces of apparatus are in series with each other, and in parallel with respect to different portions of the winding.

The author treats of the particular case of two groups of apparatus (such as incandescent lamps) without self-induction, each of which derives its potential difference from the potential divider. This arrangement is shown in the figure. The resistance and the coefficient of self-induction of the two parts AE and EB of the winding are denoted respectively by r and L ; the coefficient of mutual induction by M ; r_4 and r_5 are the resistances of the circuits ACE and EDB ; i_1, i_2, i_3, i_4, i_5 are the instantaneous currents in the various circuits ; v_2 and v_3 are the instantaneous potentional differences between A and E and between E and B. We then have—



$$v_2 = ri_2 + L\frac{di_2}{dt} + M\frac{di_3}{dt}$$

$$v_3 = ri_3 + L\frac{di_3}{dt} + M\frac{di_2}{dt}$$

Also—

$$v_2 = i_4 r_4, \ v_3 = i_5 r_5, \ v_1 = v_2 + v_3$$

$$i_1 = i_2 + i_4 = i_3 + i_5$$

Putting L=M, we deduce that—

$$\frac{v_3}{v_3} = \frac{r_4 r_3 + r_5 r}{r_4 r_5 + r_4 r}$$

which shows that the ratio of the potential differences depends only on the ohmic resistances of the circuits. It is further deduced that the current through the windings is only half that which transverses the circuit D when the circuit C is short circuited. Also the current traversing the windings is a minimum when the circuits C and D are equally loaded. W. G. R.

172. *Ohmmeter for use on Alternate Current Mains.* (Zeitschr. Elektrotechn., Wien. 17. pp. 518–520, October 8, 1899.)—This instrument, which is of analogous construction to one designed by Wilkens (see Elektrotechn. Ztschr. 1897, p. 748), is constructed by the Allgemeine Elektricitäts-Gesellschaft, of Berlin. It comprises a dynamometer, the stationary coil of which is excited as follows: The primary circuit (A) of a small transformer mounted in the interior of the apparatus, has its terminals connected to the supply mains, the potential difference of which is to be employed in measuring the insulation resistance. This transformer has two secondary coils, of which one (B) is connected directly to the stationary coil of the dynamometer, whilst the circuit of the second secondary coil (C) extends through the movable coil of the dynamometer, the ends being connected to terminals marked respectively, "Earth" and "Installation." When the instrument is connected up for use, the stationary coil of the dynamometer is traversed by a constant current from the secondary coil B, and thus produces a constant alternating magnetic field. If now a current from the secondary coil C passes from the installation to earth, the movable coil of the dynamometer turns and the pointer moves over a scale graduated in ohms. The sensibility of the instrument can be increased by giving the stationary coil as many ampere-turns as possible, which can be easily done by means of the transformer. In order that the measurements shall be made with the normal working potential difference, the coils A and C of the transformer must have the same number of turns. The readings of the instrument are, however, only correct when the potential difference at the supply mains is that for which the instrument is constructed to work. In order to determine whether this potential difference is normal without requiring a special voltmeter, the instrument is adapted to also act as a voltmeter. For this purpose it is only necessary to connect together the terminals "Earth" and "Installation" by means of a wire, and to connect the primary circuit terminals of the transformer to the supply mains as usual. The volts are then read off on a second scale arranged beneath the ohm scale. Examples, illustrated by diagrams, are given in the original paper for explaining methods of using the instrument on three-phase and other systems.

C. K. F.

173. *Alternate Current Ohmmeters.* **G. Benischke.** (Elektrotechn. Ztschr. 20. pp. 410–411, June 8, 1899.)—This is a paper read before the Elektrotechnischen Verein, Berlin, on the methods of measuring the insulation of alternate current networks by employing the normal working voltage. With continuous currents, this test is usually made with an ammeter and voltmeter, which are put successively between each wire of the network when charged to the full working pressure and earth. Similar tests can be made on alternate current circuits by using instruments of the dynamometer type. But in practice the method has several disadvantages; two separate instruments are necessary, and a calculation is required to determine the actual insulation resistance; the current measured may be not only a leakage, but also a capacity current; and if there be a fault on the circuit it may cause a serious short circuit if switched on to the main before being tested.

To obviate these defects an instrument is made by the Allgemeine Elektricitäts-Gesellschaft, consisting of a transformer and wattmeter. The primary of the transformer is connected across the mains. It has two secondaries—one connected across the thin wire coil of the wattmeter; the other, which has the same number of turns and therefore the same voltage as the primary, in series with the moving wattmeter coil between the circuit to be tested and earth. For fixed voltages the instrument is calibrated directly in ohms of insulation resistance. By short circuiting the testing terminals it is available as a voltmeter, for which purpose a second scale is added. The instrument is neat and compact. It is also adapted for attachment to a station switchboard. In high pressure circuits the insulation must first be determined at the lower voltage to ensure that there is no bad fault, and then tested when under full pressure by means of electrostatic voltmeters. In three-phase networks a fault in the system can be detected by connecting a voltmeter from the neutral point of the star connection at the far end of the line to earth. In order to determine in which wire the fault lies, the voltmeter must be connected successively between each wire and earth. In the discussion **Görges** pointed out that capacity currents are liable to be mistaken for leakage. In the Elektricitätswerk Wynan, Switzerland, the capacity current for 75 miles of overhead line at 9,000 volts amounted to half an ampere. With concentric cables in a three-phase system, the difference in capacity of the lines has a similar effect to leakage on the potential of the neutral point of the star connections. **Wilkens** pointed out that insulation tests made by connecting the circuit directly to the mains can be rendered perfectly safe, in case of a fault by putting a suitable known resistance in series. L. B.

174. *Measuring the Speed and Lag of Alternate-current Motors.* **R. Seemann.** (Elektrotechn. Ztschr. 20. pp. 764–766, November 2, 1899.)—This apparatus is constructed by Siemens and Halske, of Charlottenburg, and simultaneously determines the speeds of the motor and of the dynamo by means of two revolution-counters which can be thrown into and out of gear electrically. The difference between the two numbers of revolutions, reduced to equal numbers of poles, gives the lag. The two counters each comprise a worm spindle capable of being coupled to the respective shafts, and in connection with each worm, there is arranged a worm-wheel mounted on a spring-controlled lever which bears an armature arranged in conjunction with an electromagnet, so that when the electromagnets are connected up in the same circuit and energised, the two worm-wheels will be brought simultaneously into engagement with their worms. It is obvious that, by means of a chronograph and the above counters, the speeds of the dynamo and motor can be determined simultaneously, the percentage lag being obtained from the equation—

$$s = 100\left(\frac{u_1 - u_2}{u_1}\right) = 100\left(1 - \frac{u_2}{u_1}\right)$$

where s = the lag; u_1 the number of revolutions made by the dynamo, and u_2 the number of revolutions made by the motor in the same time. C. K. F.

175. *Platinum-clay Resistance Material.* **W. C. Heraeus.** (Zeitschr. Elektrochem. 6. pp. 43–46, July 13, 1899.)—The effect of alloying base metals such as iron or manganese with platinum is generally to produce a brittle compound; such alloys cannot very easily be used for resistance wire. As a substitute for metallic resistances, Küch mixes about 60 per cent. of platinum with 40 per cent. of clay. If rods of this mixture are heated to the melting-point in a reducing atmosphere, a stable compound results. With these precautions, the percentage of platinum may be diminished to 10 per cent. before conductivity is lost; percentages from 10 to 15 of platinum are best for most purposes. The degree of conductivity depends upon the formation of platinum-silicium, this occurs at temperatures over 1,200° C.; great care is therefore necessary in the heating process at about that temperature. Up to white heat, the resistance increases with temperature; there is then a reversal. Wires 0·5 mm. diameter can be made, having about 14 ohms resistance per 1 cm. R. A.

176. *New Measuring Instruments by Siemens and Halske.* **A. Raps.** (Elektrotechn. Ztschr. 20. pp. 665–670, September 14, 1899. Report read before the Elektrotechnischer Verein, February 28, 1899.)—The first instrument described in the paper is a wattmeter, whose design was originally suggested by a d'Arsonval galvanometer. In order to obtain a practically uniform radial field such as that which exists in this latter instrument, the series coil of the wattmeter is made up of a number of flat copper conductors of the shape shown in fig. 1. A coil, the upper and lower portions of whose turns consist of such circular conductors, produces a practically uniform radial field. In this is pivoted the fine-wire coil, which consists of 400 turns of wire 0·1 mm. in diameter, and is connected in series with a non-inductive resistance. No metal supports are used for the coils, everything being as far as possible made of insulating material. The series conductors are slotted to prevent eddy-currents. An important feature of the new instruments is the method of air damping. This method is also used in the construction of the new switchboard ammeters and voltmeters, and is shown in fig. 2, which represents the moving part of one of these instruments. The soft-iron needle N is of the shape shown, and is sucked into a coil placed immediately below it. The damping arrangement consists of a thin circular plate P provided with a rim and attached to the spindle by means of a very thin-walled tube of hard-drawn brass. The plate P moves with a very small clearance inside a damping tube DT. A. H.

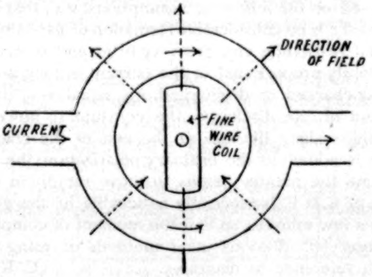


FIG. 1.

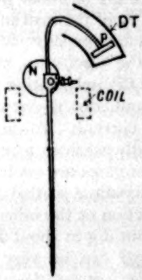


FIG. 2.

177. *Thermophone.* **G. C. Whipple** and **H. E. Warren.** (Eng. News, 42. pp. 109–110, August 17, 1899.)—A modified Wheatstone bridge with galvanometer replaced by a telephone receiver in circuit with which is placed a vibrator resembling the vibrating armature and spring of an electric bell. Resistance coils, one at a known the other at an unknown temperature, affect the balance of the bridge by their relative variations in resistance under changes of temperature. When the balance is disturbed the instrument hums : but it can be silenced by adjusting the position of a pointer, whose movement alters the relation between two branches, and whose position enables the corresponding temperature of the distant resistance coil to be read off on a dial-scale. A. D.

178. *Instrument for Determining the E.M.F. of Accumulators.* (Zeitschr. Elektrotechn., Wien. 17. pp. 454–455, August 27, 1899.)—In this instrument, which is due to R. Hopfelt, of Berlin, the times at which the fall in the electromotive force takes place at the end of the discharge, and at which it increases at the end of the charge, can be determined when currents are passing through the accumulator. The instrument consists of a kind of differential galvanometer, *e.g.*, a Weston voltmeter wound with two coils, one of which is connected through a suitable resistance directly to the terminals of the battery, whilst the other is connected in parallel with a resistance in the main circuit of the accumulator. The latter coil must be so connected to the series resistance that, when the accumulator is being discharged, the current will pass through it in such a direction that the effects of the two coils on the movable system of the instrument will be added. This is necessary, since the terminal potential difference is here smaller than the E.M.F. The theory of the instrument is based on the following assumptions, viz., that in a lead accumulator, so long as there is no considerable formation of gas-bubbles on the electrodes, the internal resistance changes very little, and moreover that the polarisation is very closely proportional to the current so long as the accumulator is not completely charged or discharged, *e.g.*, equal to c_p times the current. Towards the end of the discharge, the constant c_p however rapidly assumes a relatively high value ; likewise at the end of the charge, when gases are evolved, there is added to the ordinary polarisation, the gas polarisation, so that at this time the pointer begins to move rapidly in one direction or the other. A rise of E.M.F. is especially noticeable in charging, amounting to about 0·5 volt in a few minutes, so that the moment of complete charge can be very easily observed. Various other methods of using the instrument are described with reference to diagrams. C. K. F.

179. *Instruments for Three-Phase Circuits.* (Ind. Élect., 8. p. 436, October 10, 1899. Abstract of paper read by R. Arno, before the National Congress of Italian Electricians at Como.)—A paper dealing with the principles underlying the construction of certain forms of wattmeters and energy meters for use on three-phase networks. A. H.

180. *Measuring the Frequency of Alternate Currents.* **H. V. Carpenter.** (Elect. World and Engineer, 34. pp. 198–199, August 5, 1899.)—The method consists in turning a wire stretched between the poles of an electromagnet, and carrying the alternating current till its natural period is the same as that of the current, and calculating the periodic time from its length, weight, and the tension. The accuracy of the method is stated to be within one-fifth of 1 per cent. W. G. R.

181. *Measurement of Frequency.* **H. W. Smith.** (Elect. Engin. 24. pp. 466–467, October 13, 1899 ; from the "Technology Quarterly.")—A weighted tuning fork, electrically driven, is provided with a sharp-pointed style attached to one of its prongs ; this style vibrates over a smooth surface formed by two blocks of ivory separated by a sheet of platinum about 0·02 inch in thickness. This contact maker is connected in series with a telephone and attached to the source of alternate current. When the fork is set in vibration the style makes contact at the middle of each stroke of the prong, and if the frequency of the alternate current is the same as that of the fork the contacts will occur at the same point in each successive current wave ; there will then be a steady sound in the telephone or no sound, depending on the difference of phase between the fork and the current. If the frequency of the fork and the current differ there will be " beats " and the weights on the fork are shifted until there are no beats, and, as the fork has been previously rated, the frequency of the current is determined. This paper then deals with a method of driving the fork electrically which is a modification of one given by W. G. Gregory in the Phil. Mag. (December, 1889, p. 400). E. C. R.

182. *Frequency Indicator.* **G. J. Yundt.** (Elect. World and Engineer, 34. p. 344. September 2, 1899.)—Suspended from a wooden stand is a vertical phosphor bronze wire (No. 26) which passes between the soft-iron pole-pieces of a permanent horseshoe magnet and conveys the current whose frequency is to be determined. The wire is stretched tight by a weight attached to its lower end, and immediately above the weight is a wedge of brass whose edge presses against the wire. A movable bridge, which is free to slide up and down a vertical scale, serves for adjusting the length of the vibrating wire, and so determining the corresponding frequency of the current. A. H.

183. *Phasemeter for Alternate Currents.* **R. Arnò.** (Écl. Électr. 21. pp. 225–226, November 11, 1899; also Elettricista, t. viii. p. 203, September 1, 1899.)—This instrument consists of a combination of an electro-dynamometer having its coils separate, and an instrument to produce a Ferraris field having two separate coils fixed at right angles with an extra closed-circuit movable coil placed inside them.

Let I_1 and I_2 be the two currents under test, α the deviation and ϕ the difference of phase, then we have in the dynamometer—

$$I_1 I_2 \cos\phi = \kappa'\alpha,$$

and in the Ferraris instrument—

$$I_1 I_2 \sin\phi = \kappa''\beta,$$

whence—

$$\tan\phi = \kappa\frac{}{\alpha}$$

Now to get a result by only one test the two instruments are connected together so that the two currents pass through their respective coils in both, which are separated by a copper plate to prevent mutual influence; the readings are taken on both instruments from which the tangent of the difference ϕ is deducted. E. C. R.

184. *Permeameter.* **C. P. Poole.** (Amer. Electn. 11. p. 429, September, 1899.) —This is a permeameter intended for workshop use. It is of the dynamo type, with massive pole-pieces and armature-core. The only point of novelty is that the speed is adjusted so that the permeameter is direct-reading. A voltmeter connected to the brushes indicates 1 volt for each 1,000 gausses in the specimen field-magnet core. For the theory of permeameters of this type see Abstract No. 618 (1899). R. A.

185. *Magnetic Intensity Variometers.* **M. Eschenhagen.** (Deutsch. Phys. Gesell., Verh. 1. pp. 147–152, 1899.)—The earth's magnetic force is usually balanced against the force of a permanent magnet or the directive force of a bifilar suspension. Both these forces are subject to changes with time and temperature. Quartz fibres are too weak for holding the usual magnetic systems, but the author has devised a light system which can be suspended by a single quartz fibre, and which offers great constancy and special facilities for photographic registration. E. E. F.

186. *Periodic Curve Tracers.* **R. Franke.** (Elektrotechn. Ztschr. 20. pp. 802–807, November 16, 1899. Read before the Seventh Session of the Ver-

bandes Deutscher Elektrotechn. at Hanover, 1899.)—The author reviews the methods suggested by Frölich and by Joubert for tracing periodic curves. He also describes an improved form of apparatus patented by himself, for applying the Joubert method to practical measurements. It is taken for granted that the mechanism is to be used for tracing the current curves of alternators. Joubert took off the current at a given phase by means of a one-bar commutator; the current at successive phases could be determined similarly by twisting the commutator through successive angles, and by observing the corresponding steady deflections of a galvanometer. In the new apparatus the one-bar commutator is replaced by one with five sectors with narrow spaces between them. The fifth sector subtends twice the angle of either of the other four; and there are two brushes making peripheral contact at a distance apart equal to the width of the fifth sector. Such an arrangement makes contact momentarily once each revolution; the moment of contact can be readily adjusted, and the duration controlled. The five-bar commutator can be attached to the armature shaft, or it can be geared to it by means of a flexible drive. In the case of multi-polar machines change-wheels are provided, so that the commutator makes a complete turn for each period. The angular position of the contact can be adjusted by rotating a grooved wheel on the commutator. An endless cord, passing over the wheel, communicates similar angular displacements to a cylinder, around which the record paper is wrapped. The galvanometer "spot" is focussed upon the cylinder, and its position for each change in the commutation is marked by hand, with a pencil, on the record paper. Examples of curves traced by this apparatus are given, together with very clear illustrations of the mechanism. R. A.

187. *Determining the Wave Form of Polyphase Alternating Currents.* **H. J. Ryan.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 365–377; Discussion, pp. 377–380, August and September, 1899.)—This method may be regarded as a development of that devised by Duncan (see Trans. Amer. Instit. Elect. Engin. 9. pp. 179 *et seq.*), wherein the current, whose wave form is to be determined, is passed through the fixed coil of a dynamometer, whilst the movable coil of the dynamometer is included in a circuit containing an accumulator and a contact-maker on the rotary shaft of the dynamo or motor. Instead of using the accumulator and contact-maker, the author employs an "impulse" transformer having a closed magnetic circuit of soft, pure iron, with the portion enveloped by the primary and secondary coils much restricted in area as compared with the remaining portion of the magnetic circuit, so that the flux through the core will cause saturation during 97 per cent. of the time; the greater portion, therefore, of the secondary E.M.F. time-integral will occur during 1·5 per cent. of the time of one alternation and this E.M.F. will thus be delivered with great suddenness at the time when the exciting current passes through zero. In order to produce an impulsive current by this means at different parts of the cycle, so as to obtain different points on the curve, the phase of the exciting current of the impulse transformer can be changed by phase-changing transformers or by an induction motor. In cases where the plus and minus alternations are different, one or more aluminium cells can be placed in series with the impulse secondary so as to cut off one or other side of the alternating impulse as desired. Full details of the connections and of apparatus employed, including an auxiliary transformer for compensating for the residue of the secondary E.M.F., together with examples of curves compared with those obtained by the contact-maker method, are given in the original paper.

In the discussion which followed, **C. P. Steinmetz** and **C. A. Adams** described improved forms of contact-maker which have worked well in practice and **C. P. Mathews** described a method of obtaining wave forms in which a galvanometer of the oscillograph type and aluminium cells are employed.
C. K. F.

188. *Photographic Current Curves.* **J. Zenneck.** (Wied. Ann. 69. 4. pp. 838–853, December, 1899.)—Braun's kathode ray method may be modified so as to give current curves on to fluorescent screen itself, which may be exhibited in a lecture or photographed. To accomplish this the author imparts a lateral periodic motion to the vibrating spot of light on the screen by means of a second deflecting magnet excited by a synchronous current changing in a linear manner with the time. This current is taken off a wheel carrying a circular wire, and is inversely proportional to the length of wire in circuit at any instant.
E. E. F.

189. *Photographic Current Curves.* **A. Wehnelt** and **B. Donath.** (Wied. Ann. 69. 4. pp. 861–870, December, 1899.)—The Braun vacuum tube possesses several great advantages over other contrivances for demonstrating the variation of an electric current. Operating as it does with a kathode beam deflected by a magnet excited by the current under investigation, it offers a weightless lever whose displacement is practically perfectly proportional to the current strength. The authors have improved the arrangement and made it available for quantitative determinations. They dispensed with the revolving mirror, as the images obtained with it were too feeble. Instead, they photographed the spot of light on the fluorescent screen on a sliding plate, and photographed, side by side with it, the sinusoidal curve of a vibrating tuning-fork, obtained by attaching a pin-hole in aluminium foil to the prong in the path of a strong beam of light. The curves reproduced are very striking. Several of them show the course of the current from a Wehnelt interrupter under various conditions of capacity and inductance in the circuit. They all show the very rapid break, which practically obliterates that part of the curve altogether. One photograph shows the curves of current and E.M.F. and their relative displacement, obtained with two independent lenses and two luminescent screens at right angles to each other.
E. E. F.

190. *Doubling the Frequency of an Alternate Current.* **J. Zenneck.** (Wied. Ann. 69. 4. pp. 858–860, December, 1899.)—The author has devised an ingenious method of doubling the rate of alternation of an alternating current by means of a stationary transformer. He does it with the aid of two "aluminium valves," or carbon-potash-aluminium cells, which, as we know, only allow the current to pass from the aluminium to the carbon electrode. The alternating circuit is split into two branches, which are wound round the core of a transformer in opposite directions. Each of the branches contains an aluminium valve, but the valve is reversed in one branch with respect to the other. The effect of this is that one-half of the alternate current passes through one branch and the other through the other branch, but in an opposite direction, so that in reality two successive maximums act upon the transformer, instead of a maximum and a minimum. This of course amounts to a doubling of the original frequency, though the new current is no longer sinusoidal. Curves taken off the secondary coil of the transformer show such a doubling distinctly. The author has not obtained any very favourable curves that way,

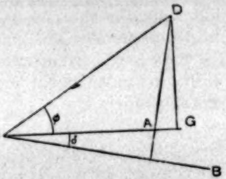
but his aluminium valves were imperfect, showing both leakage and distortion. He expects that, with better arrangements, perfect doubling could be obtained.

E. E. F.

191. *Harmonics of Rotary Currents.* **J. Zenneck.** (Wied. Ann. 69. 4. pp. 854–857, December, 1899.)—The greater the deviation of the curve of a rotary current (*drehstrom*) from the sine form, the more practically important it is to find which is the chief upper harmonic vibration and what is its amplitude with respect to the main current. The author analyses the current, considered as a four-phase current, by means of a Braun kathode ray tube acted upon by four coils symmetrically disposed, two of which are excited by one phase, while the other two are excited by a phase displaced 90° with respect to it. Now, if the current is purely sinusoidal, the curve described by the spot on the fluorescent screen will be a circle. If "over-tones" are present, these will trace themselves on the circumference of the circle just as the original curve traced itself with respect to a straight line. It then only remains to count the number of maxima or minima of the radius. If there are four maxima, the secondary periodicity will be five times that of the main current, as one has to be added on account of the revolution. The ratio of the difference between maximum and minimum radius vector to the radius of the circle indicates the ratio of the two amplitudes. In one case examined the relative periodicity was 9, and the amplitudes were as 1 : 36. E. E. F.

192. *Hysteresis.* **T. R. Lyle.** (Electrician, 43. pp. 570–571, August 11, 1899.)—If a harmonically varying magnetomotive force be applied to a closed ring of soft iron, if the flux curve differs considerably from a sine curve, and lags behind the magnetomotive force curve.

Consider a magnetic circuit round which there are n windings, and such that 10 ampere turns produce a flux σ through it. Let an E.M.F., $e \cos \omega t$, operate in this circuit. In the accompanying figure let $OA = Rc$ where R is the resistance of the circuit and c the current in it.



Draw OB behind OA by an angle δ (the flux retardation) and equal to $n\sigma c$; then if the projection of OA on any line rotating in the plane of the diagram with angular velocity ω represent the value of Rc at any instant, the projection of OB on the same line will represent the corresponding value of the magnetic flux.

Through A draw DA perpendicular to OB and equal to ωnOB (that is to $\omega n^2 \sigma c$ or ωLc where $L = n^2 \sigma =$ inductance). DA will represent in amplitude and phase the E.M.F. due to change of OB, the magnetic flux. Join OD. OD will represent in magnitude and phase the impressed E.M.F. Produce OA to G to meet the perpendicular DG to it.

Then—

$$OD^2 \text{ or } e^2 = (R^2 + \omega^2 L^2 + 2\omega LR \sin \delta) c^2 = I^2 c^2 \text{ say.}$$

Hence—

$$c = \frac{e}{I}$$

where I, the impedance,

$$=\sqrt{\mathrm{R}^2+\omega^2\mathrm{L}^2+2\omega\mathrm{LR}\sin\delta}$$

Also, if the angle AOD $=\phi$

$$e\sin\phi=\omega\mathrm{L}c\cos\delta$$
$$e\cos\phi=(\mathrm{R}+\omega\mathrm{L}\sin\delta)c$$
$$\therefore\quad \tan\phi=\frac{\omega\mathrm{L}\cos\delta}{\mathrm{R}+\omega\mathrm{L}\sin\delta}$$

so that if the impressed E.M.F. $=e\cos\omega t$

then— $$c=\frac{e}{\mathrm{I}}\cos(\omega t-\phi)$$

Thus while hysteresis increases the impedance of the circuit it diminishes the lag of the current.

The power put into the circuit $=\frac{1}{2}ec\cos\phi$

$$=\frac{1}{2}\cdot\frac{\mathrm{OA.OG}}{\mathrm{R}}$$
$$=\frac{1}{2}\cdot\frac{\mathrm{OA}^2}{\mathrm{R}}+\frac{1}{2}\cdot\frac{\mathrm{OA.AG}}{\mathrm{R}}$$

of which $\frac{1}{2}\frac{\mathrm{OA}^2}{\mathrm{R}}$ or $\frac{1}{2}\mathrm{R}c^2$ is used in heating the circuit, and $\frac{1}{2}\frac{\mathrm{OA.AG}}{\ }$ or $\frac{1}{2}\mathrm{L}\omega c^2\sin\delta$ is the power absorbed by hysteresis.

Now as $\omega=2\pi\times$ the frequency, the energy T absorbed per cycle by hysteresis is $\pi\mathrm{L}c^2\sin\delta$ or $\pi n^2\sigma c^2\sin\delta$, and as $\sigma=\frac{4\pi\mu a}{l}$ (where l = length, a = cross-section, and μ = permeability of magnetic circuit) and the induction $b=\frac{4\pi nc}{l}$ we get—

$$\mathrm{T}=\frac{b^2}{4\mu}\cdot v\sin\delta=\frac{bhv}{4}\sin\delta$$

where v is the volume of the iron and $h=\frac{b}{\mu}$.

Hence the energy T absorbed per cycle is—

$$\mathrm{T}=\frac{vbh}{4}\sin\delta,$$

or per cubic centimeter per cycle—

$$\mathrm{T}=\frac{bh}{4}\sin\delta.$$

W. G. R.

193. *Hysteresis of Cobalt.* **J. A. Fleming, A. W. Ashton,** and **H. J. Tomlinson.** (Phil. Mag. 48. pp. 271–279, September, 1899.)—The Cobalt ring used in the experiments described had the following composition :—

Cobalt	95·95 per cent.	Silicon	0·42 per cent.
Nickel	0·80 „ „	Carbon	1·36 „ „
Iron	0·91 „ „	Sulphur	trace.
Manganese	0·25 „ „	Phosphorus	trace

The test was performed ballistically, and the authors conclude that except at low inductions the hysteresis loss per cubic centimeter per cycle (W) can be expressed in either of the forms—

$$\mathrm{W}=0{\cdot}01\,\mathrm{B}^{1\cdot 6}$$
$$\text{or } \mathrm{W}=0{\cdot}527\,\mathrm{I}^{1\cdot 62}$$

where B is the maximum induction, and I is the maximum intensity of magnetisation. W. G. R.

194. *Alternating Current Theory.* **C. P. Steinmetz.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 289–316; Discussion, pp. 317–324, 1899.)—In the first part of the paper, the author deals with the representation of the power in an inductive circuit by means of a vector graphically, or by means of a complex number analytically. The E.M.F. **E** and current **I** in a circuit may be represented by two vectors in an Argand diagram corresponding to the complex numbers $\mathbf{E}=e_x+ie_y$ and $\mathbf{I}=i_x+ii_y$ respectively (where $i^2=-1$). If we take the product **EI** of the two vectors, we find that this does not correspond to the power. The power vector is, in fact, a vector whose frequency is double that of **E** or **I**, and hence it cannot be represented in the same diagram with **E** and **I**. This leads us to consider the product **EI** when the phase angle is doubled. Forming this product, and remembering that now i^2 must be put $=+1$, since a rotation of π radians for **E** or **I** corresponds to a rotation of 2π for the product, we find $[\mathbf{EI}]=(e_xi_x+e_yi_y)+i\,(e_yi_x-e_xi_y)$, where the square brackets are used to indicate a doubling of the frequency. The real component of $[\mathbf{EI}]$ gives the true power in the circuit, and the imaginary component the wattless volt-amperes. By squaring and adding the two components, the square of the total volt-amperes or apparent watts in the circuit is obtained. The author points out that $[\mathbf{EI}]=-[\mathbf{IE}]$, so that the law of commutation ceases to hold in this case. The method of representing power just explained is applied by the author to the problem of two polyphase induction motors coupled mechanically and electrically, the 2^{ary} of the 1st motor being closed by the 1^{ary} of the 2nd motor. In the 2nd part of the paper, the author considers the symbolic representation of E.M.F. and current waves of irregular shape. In many cases, instead of considering such waves, we may use equivalent sine waves. In other cases, however, especially in circuits containing capacity or periodically varying resistance or reactance (*e.g.*, alternating arcs, synchronous induction motors, oversaturated magnetic circuits, &c.), the use of an equivalent sine wave is not permissible. The author proposes to use the following symbolism in such cases. The general alternating wave of E.M.F., viz., $\mathrm{E}=\mathrm{E}_1\sin(pt-a_1)+\mathrm{E}_3\sin(3pt-a_3)+\ldots$ may be written in the form $\mathbf{E}=\sum_{n=1}^{n=\infty}{}_{2n-1}(e_n+i_ne'_n)$, where $i_n^2=-1$, the suffix n merely denoting that the components of the various terms represent different frequencies, and thus cannot be combined. If now the impedance of the fundamental harmonic be represented by $z_1=r+i(x_m+x_o+x_c)$, where x_m stands for that part of the reactance which is proportional to the frequency (inductance, &c.); x_o for the part independent of the frequency (mutual induction, synchronous motion, &c.); and x_c for the part which varies inversely as the frequency (capacity, &c.), then the impedance for the nth harmonic is $z_n=r+i_n(nx_m+x_o+x_c/n)$, and the current may be represented by $\sum_{n=1}^{n=\infty}{}_{2n-1}\dfrac{e_n+i_ne'_n}{r+i_n(nx_m+x_o+x_c/n)}$. The use of this symbolism is illustrated by numerical examples.

In the discussion, **L. Bell** called attention to the imperfection of the ordinary sine wave calculations when applied to long lines having combined inductance and capacity. **D. C. Jackson** contributed the following note on a method of treating the power vector, which he considers simpler than Steinmetz's method. Let $\operatorname{cis}\theta=\cos\theta+i\sin\theta$, so that $\operatorname{cis}\theta$ represents the operation of turning a vector through an angle θ. Writing $\mathbf{E}=\mathrm{E}\operatorname{cis}\theta$, and $\mathbf{I}=\mathrm{I}\operatorname{cis}(\theta-\phi)$, and denoting the power vector by **P**, we have $\mathbf{P}=\mathbf{EI}=\mathrm{EI}\operatorname{cis}(2\theta-\phi)=(\mathrm{EI}\cos\phi-i\mathrm{EI}\sin\phi)\operatorname{cis}2\theta$, and it is clearly seen that **P** has twice the frequency of I and E. Moreover, the ordinary commutative law is valid in this case. A. H.

195. *Phase-Angle Measurements.* **E. Place.** (Elect. World and Engineer, 33. pp. 614–616, 1899.)—The author describes the actual performances of a phase-angle instrument based upon Rayleigh's soft-iron needle device. They were interesting, though not quite satisfactory, mainly owing to a difficulty in defining the phase angle when current and voltage do not follow the sine law. E. E. F.

196. *Large Phase Displacements.* **J. Gŏrner.** (Elektrotechn. Ztschr. 20, pp. 750–751, October 26, 1899.)—In alternate-current work, phase displacements of ninety or more degrees cannot be obtained by the use of inductances or condensers. The author describes several systems of connection which gives the required high phase-difference. In fig. 1, A and B are the alternate current terminals, P and S are the primary and secondary coils of a transformer respectively. The displaced current traverses the portion *a c b*. A practically perfect independence of the voltage may be attained by using two transformers, as in fig. 2, and suitably adjusting the work in the two secondary coils. This type is used by Hartmann and Braun for their direct-reading phase-meter. E. E. F.

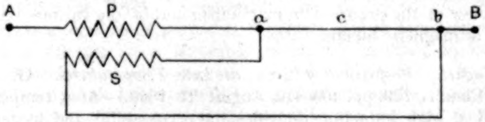


FIG I

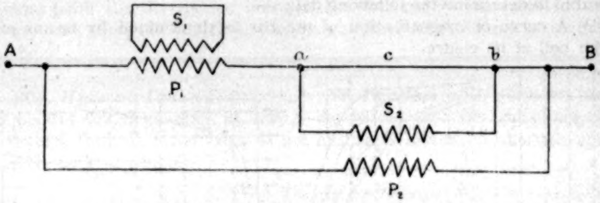


FIG 2.

197. *Magnetism and Thermoelectric Properties of Bismuth and its Alloys.* **G. Spadavecchia.** (N. Cimento, 10. pp. 161–168, September, 1899.)—The variations of thermoelectric electromotive force in alloys of bismuth and lead under the influence of magnetism increase with the variation of the magnetic field. In some alloys the changes in the thermoelectric power have different values according to the direction of the magnetisation. Under a given magnetic field the variations in the thermoelectric power progressively increase from pure bismuth up to a percentage of 0·094 of lead, and change sign between

0·094 and 0·15 per cent. Then the variations progressively increase up to a second change of sign at an alloy containing a little over 14 per cent of lead. Finally they change sign again at about 50 per cent., and diminish all the way down to pure lead. (See also 1899, Abstract No. 1931.) A. D.

198. *Molecular Susceptibilities of Paramagnetic Salts.* **A. P. Wills** and **O. Liebknecht.** (Deutsch. Phys. Gesell., Verh. 1. pp. 170–173, 1899.)—The authors determined the magnetic susceptibilities of the fluorides, chlorides, bromides, iodides, sulphates, and nitrates of chromium, manganese, iron, nickel, cobalt, copper, snd some rare metals by du Bois's method of non-magnetic solutions. E. E. F.

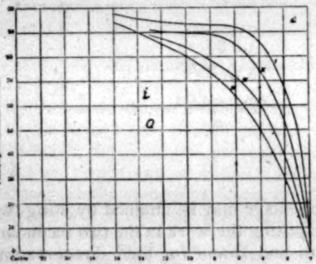
199. *Magnetism.* **J. A. Ewing.** (Instit. Civ. Engin., Proc. 138. pp. 289-311, October, 1899.)—This is the "James Forrest" Lecture which the author delivered before the Institution of Civil Engineers. It contains a general review of the progress in magnetism and of the various commercial uses made of magnetic metals. W. G. R.

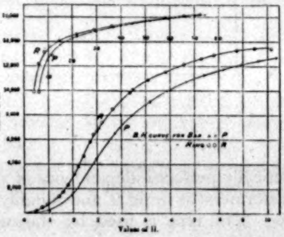
200. *Magnetic Properties of Iron at Low Temperatures.* **G. Claude.** (Comptes Rendus, 129. pp. 409–412, August 21, 1899.)—At a temperature of −185°, and at high induction densities the permeability and hysteresis loss of iron is sensibly constant, for varying magnetising forces, save for a slight tendency towards diminution.

For low induction densities the permeability and hysteresis loss diminish with the temperature in a very pronounced manner. W. G. R.

201. *Magnetic Induction in a Long Iron Bar.* **C. G. Lamb.** (Phil. Mag. 48. pp. 262–271, September, 1899.)—In order to get a sufficiently clear notion of the induction distribution in a long iron bar, and how it is produced, it is desirable to determine the following data :—

(P) A curve of magnetisation of the bar as determined by means of a search coil at its centre.





(Q) A series of curves for various fixed magnetising forces showing the distribution of induction in each case.

(R) A magnetisation curve of the bar when made into a ring, so that the induction is the same at every cross-section.

The bar used was a circular bar of Low Moor iron ; it was 0·485 cm. in mean diameter and 123·4 cm. long.

The test was made ballistically, and the accompanying curves obtained, in which the letters P, Q, R refer respectively to the three data given above. W. G. R.

202. *Magnetism and Elasticity of Rods.* **J. S. Stevens** and **H. G. Dorsey.** (Phys. Rev. 9. pp. 116–120, August, 1899.)—The authors support the rods, whose length is about 66 cms., on knife edges near the ends: in the centre of the rod, suspended from a hook, is the load causing the deflection, and in the upper surface one of the mirrors of an interferometer. Surrounding the rod is first an air space, then a chamber for the passage of a stream of water, and on the outside two series of coils for the magnetising current. The rods were of steel and also of wrought iron. The results obtained were that the modulus of elasticity of wrought iron and steel increased with magnetisation; in the case of steel little difference was observed for loads of 1 kilogramme and ½ a kilogramme, but in wrought iron the smaller load gave the greater displacement when equal magnetising forces were used. E. C. R.

203. *Distribution of Magnetic Flux.* **P. Gasnier.** (Ind. Élect. 8. pp. 414–416, September 25, 1899.)—Experiments are described for determining the distribution of flux in permanent magnets, and to ascertain whether the total flux in the case of a horseshoe magnet is modified in value by the presence or absence of the armature. A quotation is cited from a translation of S. P. Thompson's book on the electromagnet, to the effect that with a horseshoe magnet of iron or steel magnetised "*une fois pour toutes*" the flux at the bend of the shoe is a fixed quantity, unaffected by alterations of the reluctance in the rest of the magnetic circuit. The results of the present experiments are shown as curves expressing the flux in webers at different points along a horseshoe magnet, (1) with an armature; (2) without an armature. The two curves, corresponding to (1) and (2) respectively, never coincide; it is therefore concluded that the flux is different in the two cases. It appears, however, from the curves, that the flux at the middle point of the bend approaches a constant value, especially for large magnets. From this middle point the divergence between the two curves increases somewhat slowly until about one-fourth of the straight portion has been traversed from the bend. R. A.

204. *Hysteresis Loss in Transformers.* **W. Peukert.** (Elektrotechn. Ztschr. 20. pp. 674–677, September 21, 1899.)—An inquiry into the limitations of the Steinmetz formula for arriving at the hysteresis loss of all alternate current transformers, in which—

$$W = n \, . \, B^{1·6}_{max} \, p \, . \, V \, . \, 10^{-7},$$

W representing the watts lost,
n a constant depending on the quality of iron,
B the magnetic lines per sq. cm.,
p the periodicity per second,
V the total volume of the iron in cub. cm.

A table is given showing that whilst the constant n might be 0·002 for a given sample of iron at the values for B usually employed in transformers' work, the constant may increase as much as 70 or 80 per cent. when carried to higher values thus:—

$B_{max.}$	n	$B_{max.}$	n
2660	0·00222	12250	0·00256
4698	0·00221	14124	0·00301
6756	0·00224	15838	0·00372
10197	0·00246	17243	0·00393

The results of a series of tests on a transformer are tabulated for the various periodicities, viz., 24, 30, 33·3, 37·3, 41·3, 46·67, 50·67, 54·67, and the following maximum values of B, viz., 2,187, 3,522, 4,173, 5,192, 5,843, and 6,260. The author gives the following formula for arriving at a suitable B for different periodicities, &c.

$$B_{max} = \frac{0{\cdot}9E \, . \, 10^8}{4 \, . \, p \, . \, m \, . \, q}$$

Where E is the voltage,
p the periodicity,
m the number of turns of coil,
and q the cross-section of the iron in sq. cms. E. K. S.

205. *Magnetoelectric Rotations.* **W. de Nikolaiève.** (Comptes Rendus, 129. pp. 475–477, September 18, 1899.)—A brass rod is suspended inside a hollow cylinder so that the two can rotate independently, a current being sent through them in series by mercury contacts. The system is placed in a strong magnetic field. The cylinder and the rod then rotate in opposite directions, being acted upon independently by the magnet. When they are rigidly connected the system stops, or nearly stops, any residual rotation being due to want of symmetry in the distribution of the currents. E. E. F.

206. *Magnetism and Molecular Rotation.* **G. F. Fitzgerald.** (Electrician, 43. pp. 532–533, August 4, 1899.)—Although Lord Kelvin has discarded the gyrostatic hypothesis of matter as unable to account for the Zeeman effect, the author points out "a modification of Lord Kelvin's molecule by which the difficulty of producing thin lines is surmounted, while rotation of the plane of polarisation is produced by the rotation of part of the molecule. Imagine one of Lord Kelvin's spherical atoms immersed in a soft jelly. It consists of a thin spherical shell attached to the jelly. Inside this place a concentric spherical shell, separated from the first by a symmetrical system of perfectly smooth, non-conducting springs, so that the inside sphere may be able to turn round freely in any direction inside the outer one. Inside the inner sphere is suspended centrally, by a symmetrical system of springs, a heavy particle. This system can, by the oscillation of the inside heavy particle, emit a vibration of a definite frequency, *i.e.*, a thin line to the spectrum. Now, if the outer sphere be positively and the inner one negatively electrified, and the whole be subject to a growing magnetic induction, the outer sphere will be given a twist in one direction and the inner in the opposite direction. The attachment of the outer sphere to the jelly will prevent it from taking up a continuous rotation, but the inner sphere will rotate round the diameter parallel to the magnetic induction, and, being supported by perfectly smooth springs, will continue rotating as long as the magnetic induction lasts. When the magnetic induction ceases this will produce a twist on the rotating electrified sphere which will stop its rotation. During its rotation the sphere will carry round with it the central heavy particle. If this latter be vibrating, its vibrations will be affected by the rotation, and if it be kept in vibration by a plane polarised wave motion, traversing the jelly in the direction of the axis of rotation, this rotating molecule will react upon the jelly in such a way as to produce a rotation of the plane of polarisation such as is required to illustrate the Faraday rotation." E. E. F.

207. *Magnetic Shielding.* **A. P. Wills.** (Phys. Rev. 9. pp. 193–213, October, 1899.)—A theoretical discussion of the shielding effects produced by

triple concentric spherical and triple coaxial cylindrical shells. The author refers to the work of du Bois (see 1898, Abstract No. 954) on this subject, and deduces expressions for the shielding effect due to triple shells in terms of the geometrical data of the shells and the (constant) permeability of the material. The paper contains three sets of diagrams referring to uni-, bi-, and tri-lamellar shields respectively, and showing the variation of the shielding effect with thickness of shell. A. H.

208. *Electric Railways and Magnetic Observatories.* **J. Edler.** (Deutsch. Phys. Gesell., Verh. 1. pp. 174–180, 1899.)—Measurements with an intensity variometer, carried out in Berlin and Spandau, show that in the case of an electric railway with a return along the rails the distance between the railway and a magnetic observatory should not be less than 8 km. For the most delicate measurements a distance of 15 km. does not guarantee absolute safety, but special tests must be made for each individual case. E. E. F.

209. *Magnetic Elements in Italy.* **L. Palazzo.** (Accad. Lincei Atti, 8. pp. 22–28, July 2, 1899.)—The author gives the values of the magnetic elements at twenty-three stations observed in 1891–2. The stations were chosen so as to investigate the disturbances due to volcanic rocks. (See also 1898, Abstract No. 270.) W. W.

REFERENCES.

210. *Electrolytic Interrupter.* **W. Ziegler.** (Wied. Ann. 69. 3. pp. 718–719. November, 1899.)—A claim of priority by the author for himself and F. Richarz. Refers to paper by H. T. Simon (see 1899, Abstract No. 1919). E. E. F.

211. *Wehnelt and Caldwell Interrupters.* **M. Lamotte.** (Écl. Électr. 21 pp. 41–46, October 14th; pp. 127–137, October 28, 1899.)—On the form of current produced in, the difference of potential between the terminals of, and the energy dissipated in, liquid interrupters.—(Pp. 180–184, November 4th) Illustrating modifications of Wehnelt and of Simon and Caldwell interrupters.—(Pp. 250–256, November 18th) Explanation and application of Wehnelt interrupter and work of E. Lecher.

212. *Animal Electricity.* **W. S. Hedley.** (Elect. Rev. 45. pp. 468–469, September 22, 1899.)—Abstract of Burdon-Sanderson's Croonian Lecture. H. B.

213. *Electricity before Volta.* **E. de Fodor.** (Zeitschr. Elektrotechn., Wien. 17. pp. 563–569, November 5, 1899.)

214. *Electric Progress.* **E. J. Houston.** (Cassier, 17. pp. 145–153, December, 1899.)—Historical data, both purely scientific and technical.

215. *Sounds emitted by the Electric Arc.* **F. J. Jervis-Smith.** (Electrician, 44. p. 16, October 27, 1899.)—Note on the sound emitted by an arc on making the circuit of an electrolytic interrupter.

216. *Alternating Currents of very High Frequency.* **W. G. Royal-Dawson.** (Instit. Elect. Engin., Journ. 28. pp. 655–658, August, 1899.—Abstract of paper read before Students' Section.)

217. *Volta and the Voltaic Cell.* **A. Righi.** (Elect. Rev. 45. pp. 694–696, October 27, 1899.)—A lecture delivered in Como, September 18, 1899.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

218. *Place of the New Constituents of the Atmosphere in the Periodic System.* **J. L. Howe.** (Chem. News, 80. pp. 74–76, August 18, 1899.)—The author adopts, with slight modifications, Venable's form of Mendeléef's periodic table, and considers helium, neon, and argon to be the first three members of the eighth group. These three elements form a transition between the strongly electronegative halogens and the electropositive alkali metals. Neon is placed in the same horizontal line with fluorine and is the transitional element between that halogen and sodium, whilst argon lies between chlorine and potassium. Helium is placed in the same line with hydrogen and therefore precedes lithium; the corresponding halogen is, however, unknown. Too little is yet known of krypton, metargon, and xenon to allow the position of these elements to be settled; they will probably find a place in the eighth group. N. L.

219. *Relations between Properties of the Elements and their Atomic Weights.* **W. Sander.** (Elektrochem. Ztschr. 6. pp. 133–137, October, 1899.)—Remarks on the periodic nature of the properties of the elements. The author gives curves to exhibit this periodicity in the case of (*a*) linear coefficient of thermal expansion, (*b*) migration-velocity in normal solutions, (*c*) metallic conductivity, (*d*) potential-difference between a metal and a normal solution of one of its salts. In the last case the periodic curve drawn by the author does not suffer from want of novelty, as it contains no less than five double-points. F. G. D.

220. *Absorption of Water in Hot Glass.* **C. Barus.** (Phil. Mag. 47. pp. 461–479, 1899.)—Continuation of the author's work (see 1899, Abstract No. 1045) on the solution of glass in water at high temperatures (210° C.) and pressures. The apparatus used was the same as that described in previous papers. The first result of the reaction is an opaque layer, after which the aqueous silicate appears as a clear transparent viscous thread inside the glass capillary. The compressibility rises at first rapidly, attains a maximum, and then falls off to the probable value for pure water at 200° C. The action shows a definite limit when the solution has reached a certain concentration, which would appear to be in favour of the view that one is dealing with ordinary solution or with the formation of a definite compound. The author, however, adduces reasons for viewing the solution as *colloidal*. He regards the first or opaque stage as the swelling of a coagulated colloid in contact with its solvent. The subsequent clear stage is regarded as due to the fusion of this *saturated* and coagulated colloid. According to the author the reaction considered as a thermodynamic process is a march through the *critical region* of certain phases of the water-glass in question. F. G. D.

221. *Function of the Medium in the Process of Solution.* **J. W. Brühl.** (Zeitschr. Phys. Chem. 30. pp. 1–63, October 13, 1899.)—The phenomena of tantomerism or isodynamic change are eminently adapted to the investigation of processes of solution, and for this purpose the behaviour of methylic and ethylic mesityloxidoxalate in various media was studied, the conversion of the enolic into the ketonic form of these substances being readily determined spectrometrically, since the refractive and dispersive powers of the two isomerides are widely different. The experiments were carried out at the ordinary temperature, and the effect of the process of dissolution itself, of dilution, and of the continued action of the solvent was examined. Neither mere solution of the substance nor dilution produces isomeric change, these processes being, in the main, analogous to vaporisation; whilst the specific, chemical action of the solvent, as manifested by the passage of the enolic to the ketonic form, is only exerted under the influence of time. In this respect the effect of chloroform is extraordinarily small; benzene, carbon bisulphide, and α-bromonaphthalene are considerably more active; and in methyl or ethyl alcohol the isomeric change takes place comparatively quickly. In all cases the reaction tends towards the complete conversion of the one form into the other, and not towards a state of equilibrium. The formation of the ketonic form is considered to be preceded by the ionisation of the dissolved enolic isomeride, and in this latter process the physical properties of the medium may be expected to have an important influence. Thus it is observed that isomeric change occurs most readily in those media which possess a high dielectric and dissociating power; with these properties are usually associated a high specific heat and high heats of fusion and vaporisation. N. L

222. *Reciprocal Solubility of Liquids.* **G. Bruni.** (Accad. Lincei Atti, 8. pp. 141–149, September 3, 1899.)—The author studies the equilibrium of mixtures of water and methylethylketone in which ethyl alcohol is always present in the proportion of 1·5 per cent. of the total quantity of the mixture. Taking concentrations as abscissæ and temperatures as ordinates, he obtains a *closed* oval curve. The curve conforms to the law of the straight diameter, *i.e.*, the locus of the middle of chords parallel to the axis of the abscissæ is approximately a straight line. He also experiments on the temperature of solidification of the mixtures. A. G.

223. *Solubility-coefficients of Liquids.* **A. Aignan** and **E. Dugas.** (Comptes Rendus, 129. pp. 643–645, October 23, 1899.)—The authors determine the coefficients of mutual solubility of two liquids by a method which does not appear to differ in principle from that used by Nernst. The two liquids are shaken in a graduated tube and the changes of volume read off. Two observations with different initial volumes give the two coefficients required. Three cases are distinguished.

1. The two liquids do not react with each other. The authors assume there will be no contraction or expansion of total volume.
2. The liquids combine. The authors assume there will be contraction of volume.
3. Cases where there are in reality *more* than two components, although only two are supposed to be present.

From their experiments the authors conclude that aniline and water do not react, but that amyl alcohol and water do. They further conclude that the pure amyl alcohol of fermentation is a mixture. F. G. D.

224. *Hydrates in Solution.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 551–554, November, 1899.)—The author makes some deductions from the mass-law concerning hydrates in solution. His conclusions are :—

1. Hydrated electrolytes are decomposed by dilution.
2. The presence in solution of a hydrated electrolyte will not account for

variations from Ostwald's dilution law, except in so far as it is not permissible to treat the concentration of the water as constant.

8. Treating the concentration of the water as constant, the ratio of the concentrations of a hydrated and a dehydrated ion will remain the same, provided there is no secondary electrolytic dissociation. F. G. D.

225. *Origin of Symmetry in Crystals. Polymorphism.* **F. Wallerant.** (Comptes Rendus, 129. pp. 775–778, November 13, 1899.)—The symmetry of crystals is considered as the result of the progressive transformation of limited into real elements of symmetry; the chemical molecules, exercising on exterior points actions which distribute themselves nearly symmetrically with regard to certain elements, group themselves into fundamental particles having geometrically limited elements, and these, in their turn, form complex particles, having a real symmetry. The limited elements of the complex particles finally become the elements of the crystal groupings. Should the angles between the limited elements of the fundamental particle differ from those between the angles of a polyhedron, the symmetry of the complex particle, though containing the same number of fundamental particles, may vary. The networks will be identical, or only slightly different, but the real elements of one form which are wanting in another become the real elements of the crystal groupings in the latter. If the external conditions vary, the fundamental particles may themselves undergo modification, and the symmetry of the complex particle may vary by the transformation of limited into real elements, and inversely. N. L.

226. *Formation of Glauberite.* **J. H. van't Hoff** and **D. Chiaraviglio.** (Preuss. Akad. Wiss. Berlin, S.ber. 42. pp. 810–818, November 2, 1899.)—This investigation forms another of the series of researches undertaken with the view of explaining the Stassfurt salt deposits. The previous investigations (see 1899, Abstract No. 1939) have dealt with the more soluble chlorides and sulphates of potassium, sodium, and magnesium. The present one deals with the less soluble sulphates of calcium and the double sulphates of calcium and magnesium, and calcium and sodium. J. B. H.

227. *Transformation of Styrolene by Light.* **G. Lemoine.** (Comptes Rendus, 129. pp. 719–722, November 6, 1899.)—Styrolene or cinnamene, C_8H_8, changes by heat in darkness into a polymer, metastyrolene. This same polymerisation is produced at ordinary temperatures by sunlight, but slowly (in one hour from 1 to 3 per cent.); the mixture remains homogeneous, for the metastyrolene dissolves in styrolene in excess. The blue and ultra-violet radiations are especially active in producing the change. The principal action of the light is to *accelerate* an exothermic transformation, which would be produced in darkness at the same temperature, but much more slowly. J. J. S.

228. *Guttapercha.* **Spranger.** (Archiv. Post. Tele. 23. pp. 939-948, December, 1899.)—This paper is an account of the distribution and properties of the gutta plant, statistical figures as to import, mode of purification, and the physical and chemical characteristics of the purified material chiefly taken from E. Obach's paper (see 1898, Abstracts Nos. 537 and 831), and also from *Gummi, Guttapercha and Balata*, by Franz Clouth, Leipzig, 1899. O. J. S.

229. *Solidification of Hydrogen.* **J. Dewar.** (Comptes Rendus, 129. pp. 451–454, September 4, 1899. Also Nature, 60. p. 514, September 21, 1899:

paper read before the British Association.)—In order to obtain solid hydrogen, a small double-walled test tube was filled with the liquid and suspended in a bath of liquid hydrogen contained in a larger double-walled tube. The pressure was then diminished to 10 mm., but no solidification occurred. It is subsequently shown that this is due to superfusion. In the course of measurements of the boiling-point of liquid hydrogen under diminished pressure, made by means of electrical resistance thermometers, a small quantity of air leaked into the apparatus and solidified; under these circumstances the hydrogen solidifies to a kind of solid foam when the pressure is reduced below 60 mm. To decide whether this foam is really solid hydrogen, a flask of 1 litre capacity, to which a long glass tube and a small manometer were sealed, was filled with hydrogen and closed. The glass tube was immersed in liquid hydrogen boiling under reduced pressure. At 30–40 mm. the latter solidified to a mass of foam, and it was found that the narrow tube was full of a transparent solid, which, however, enclosed some gas bubbles near its surface. The maximum density of the liquid was 0·086. Solid hydrogen melts when its vapour pressure reaches 55 mm. The melting-point was determined by two hydrogen thermometers; resistance thermometers are unreliable at these low temperatures. The temperature of the solid hydrogen was 16° absolute at 35 mm. At 760 mm. liquid hydrogen boils at 21°, the vapour pressure of liquid hydrogen (in mm.) is therefore approximately represented by $\log p = 6{\cdot}7341 - 83{\cdot}28/T$, from which the freezing-point (at 55 mm.) is calculated to be 16·7° absolute. The freezing-point on the absolute scale is therefore almost half the critical temperature (30° to 32°).

T. E.

230. *Heat of Oxidation of Tungsten.* **Delépine** and **Hallopeau.** (Comptes Rendus, 129. pp. 600–603, October 16, 1899.)—The authors have determined the heats of oxidation of W and WO_2 with the following results:—

$$W + 3O = WO_3 + 196{\cdot}3 \text{ cal. (const. press.)}$$

$$WO_2 + O = WO_3 + 64{\cdot}9 \text{ cal. ,, ,,}$$

whence— $$W + O_2 = WO_2 + 2 \times 65{\cdot}7 \text{ cal. ,, ,,}$$

They employed the calorimetric bomb, using oxygen at 25 atmospheres for W, and at 15 atmospheres for WO_2, and avoided the use of iron wire, substituting for it 0·01–0·03 gr. camphor, which was ignited by 0·01 grm. guncotton. Comparisons are made with other heats of oxidation, and deductions made therefrom by means of Berthelot's principle of maximum work. Tungsten does not reduce silica, alumina, magnesia, nor oxide of zinc. On the other hand, it easily reduces the oxides of antimony, lead, and copper at the temperature of an ordinary Bunsen flame. F. G. D.

231. *Direct Determination of Heat of Formation of Aluminium Bromide.* **N. Beketoff.** (Acad. Sci. St.-Pétersbourg, Bull. 10. pp. 79–81, 1899.)—The heats of formation of most chemical compounds are determined by indirect methods. Since the indirect method involves the determination of the heats of a number of reactions, the final result will involve all the errors made in these determinations. The author has determined by a *direct* method the heat of formation of Al_2Br_6, and finds it to be 41,000 calories—a value which is intermediate between that given by Thomsen (40,000) and that determined by Berthelot (42,000). The method of experimenting consisted in introducing accurately weighed quantities of bromine into an aluminium vessel. The

bromine was sealed up in small glass spheres, which were wrapped up in aluminium foil, aluminium filings being packed on the top of the spheres. Since bromine readily attacks aluminium at ordinary temperatures, the reaction commenced as soon as the glass spheres were broken. The aluminium vessel into which the spheres were dropped could be lowered into a water calorimeter, the thermal capacity of which was such that a temperature rise of not less than 2 and not more than 3 degrees was produced, so that the loss of heat by radiation during the experiment was very small. A. H.

232. *Velocity of Detonation of Acetylene.* **Berthelot** and **Le Chatelier.** (Comptes Rendus, 129. pp. 427–434, August 28, 1899.)—The acetylene was exploded in horizontal glass tubes about 1 m. long and of 2 mm. to 6 mm. in diameter, and was operated with at various pressures between 5 and 30 kg. per sq. cm. The velocity was registered by a falling photographic apparatus, released at the moment of detonation. The image of the horizontally moving flame in the tube, combined with this vertical movement, gave a curve on the photograph, from which at any point the velocity could be found. In some cases the trace was almost a straight line, but in others it showed a velocity increasing to a maximum. The results indicate that the velocity depends upon the initial pressure of the gas, from about 1,000 m. per sec. at 5 kg. per sq. cm. to 1,600 at 30.

The differences in character between the case of acetylene and the explosion of, say, oxygen and hydrogen, is pointed out. In their case bodies are formed which dissociate at temperatures reached in the explosion, so that the action is not so uncontrolled as when the products are those of decomposition only. F. T. T.

233. *Gas Reactions in Chemical Kinetics.* **M. Bodenstein.** (Zeitschr. Phys. Chem. 29. (I.) pp. 147–158, (II.) 295–314, (III.) 315–350, (IV.) 429–448, (V.) 665–699, and (VI. and VII.) 30. pp. 113–139, May–October, 1899.)

I. Gas reactions have the advantage over those in the liquid state that they can be extended over wide temperature intervals (200°–300°). The approximate uniformity of the temperature coefficient of the latter arises from the fact that all have been investigated within about the same range of temperature: by theory a falling off at high temperatures of the rate of increase of reaction velocity is to be expected, as is in fact found in the case of the following gases. "Pseudo-equilibrium" has been put forward experimentally by Pélabon and Hélier, and theoretically by Duhem, and is now investigated by the author.

II. The theory is tested with HI between 283° and 508°. The heat-production (Wärme-tönung) q, calculated from the coefficients of equilibrium, is found to vary considerably with the temperature, and is of the form $A+BT+CT^2$, and therefore K, k_1 and k_2, each of the form—

$$\log K = -\frac{A}{RT} + \frac{B}{R} ln T + \frac{C}{R} T + \text{const.}$$

The relation $K = k_1/k_2$ is found to hold between 356° and 508° within the somewhat wide limits of experimental error; the differences below 356° (up to 35 per cent.) may be due to the failure of iodine vapour to obey the laws of an ideal gas. The value of q extrapolated to 20° agrees but poorly with that observed in the calorimeter. The increase of velocity of decomposition for 10° rise of temperature between 300° and 500° is somewhat less (1·9 to 1·5 times) than that observed for liquid reactions at ordinary temperatures.

III. The combination of hydrogen and sulphur is found to be practically complete at 300°–500°, and the inverse reaction only reached a few tenths per cent. after long heating; Pélabon's "pseudo-equilibria" are therefore only erroneous observations due to shortness of time. The velocity of combination is determined at 356° for varying H_2 concentration with constant vapour pressure of sulphur, and also for varying concentrations of sulphur, and found to be proportional to the former and nearly to the square root of the latter, the formula, $dx/dt=k(a-x)(b-x)^{\frac{1}{2}}$, where *a* and *b* are the original concentrations of hydrogen and sulphur, agreeing best with the results. This the author explains by supposing that the reaction takes place in three stages—

$$S_8=4S_2$$
$$S_2=2S$$
$$H_2+S=H_2S,$$

of which the first is negligeably slow, the second (almost) negligeably fast, and the third is that of which the velocity is measured. The concentration of S must then be proportional to the square root of that of S_2, and the latter will be practically proportional to that of S_8. The increase of velocity for every 10° rise of temperature is comparable (1·4 to 1·8) with that observed in liquid reactions.

IV. Hydrogen selenide decomposes, and likewise is formed much faster, when the walls of the containing vessel are coated with selenium, and the proportionality between the velocity and the quotient, surface/volume, indicates that the reaction takes place entirely on the surface. The equilibrium attained is the same for both formation and decomposition when sufficient time is allowed, thus disproving Pélabon's "pseudo-equilibria." Other criticisms of Pélabon's paper are also given.

V. The combination of H_2 and O_2 between 482° and 689° is studied by passing the gases, mixed in different proportions, through clean porcelain tubes, and measuring the diminution in volume. The time spent by each portion in the heated tube is calculated and the velocity of combination determined. The reaction is found to take place exclusively on the walls of the tube, and is shown by the satisfactory constancy of the calculated coefficient to be *trimolecular*, in accordance with the equation—

$$2H_2+O_2=2H_2O.$$

The velocity varies with the tube used, and its temperature coefficient is somewhat uncertain. The formula—

$$\log k=-\frac{16298}{T}-48{\cdot}455\log T+163$$

is given. At the highest temperatures the transition to an explosive reaction was clearly shown, in accordance with van't Hoff's explanation, the velocity rising, owing to evolution of heat, more rapidly than the walls of the tube could equalise. Hélier's "pseudo-equilibrium" was not observed.

VI. Various forms of baths and thermostats for constant high temperatures are described, applicable from 100° to 700°.

VII. Summary of results. B. B. T.

234. *Pseudo-Equilibria.* **P. Duhem.** (Zeitschr. Phys. Chem. 29. pp. 711–714, September 15, 1899.)—A reply to the criticisms of Bodenstein on Pélabon's work. The author points out that Bodenstein may have erred in overlooking the solvent action of melted sulphur on the sulphuretted hydrogen produced in the reaction between hydrogen and melted sulphur. If enough sulphur were present this might make the reaction appear unlimited, in accordance with Bodenstein's results. As Pélabon has found that a very considerable absorption of sulphuretted hydrogen by sulphur does occur, and as Bodenstein does not appear to have allowed for this, the author challenges the accuracy of Bodenstein's results. F. G. D.

235. *Chemical Equilibrium in Systems of Two and Three Bodies.* **V. Kouriloff.** (Acad. Sci. St.-Pétersbourg, Mem. 8. 4. pp. 1–93, 1899.)—An elaborate treatise on the subject. Chapter I. deals with the experimental methods employed by the author, including the determination of solubility, lowering of freezing-point, rise of boiling-point and electrical conductivity. Details regarding all the precautions employed are given. Chapter II. is concerned with the conditions of equilibrium in a system of two bodies, the following typical cases being studied in detail: (1) β-naphthol and benzene; (2) β-naphthol and picric acid; (3) triphenyl-methane and benzene; (4) picric acid and benzene; (5) ammonia and ammonium nitrate. The following tables contain some of the results of these experimental investigations:—

1. β-NAPHTHOL AND BENZENE.

Temperature	121	112·5	106·5	95·3	89·8	87	77·4	71·5	67	32·5	12
Molecules of $C_{10}H_7OH$ in 100 molecules of mixture	100	79	71·6	51·8	44·8	39·3	25·1	17·8	14·6	3·6	1·83

2. β-NAPHTHOL AND PICRIC ACID.

Temperature	122·2	117	120·2	146	151	156·4	150·8	136·4	127	117	121
Molecules of picric acid in 100 molecules of mixture	100	95·6	85·4	70·2	62·9	51·4	35·2	23·1	12·4	4·87	0

3. TRIPHENYL-METHANE AND BENZENE.

Temperature	87·3	83·5	77·6	77·1	78·2	74·7	71	60·6	52·1	40	24·5
Molecules of triphenyl-methane in 100 molecules of mixture	89·7	82·1	73·5	59	49·7	32·5	26·8	15·1	10	4·86	1·97

4. PICRIC ACID AND BENZENE.

Temperature	122·2	111	95·1	88·8	85·6	83·8	77	67	40·4	15	10
Molecules of picric acid in 100 molecules of mixture	100	84·5	63·2	56·6	51·9	48·8	37·6	20·2	7·59	2·1	1·74

5. AMMONIA AND AMMONIUM NITRATE.

Temperature	168 (about)	109·8	94	68·8	33·3	0	−10·5	−34	−44·5	−60	−80 (about)
Molecules of NH_4NO_3 in 100 molecules of $NH_4NO_3+NH_3$	100	73·2	67·3	53·8	45·8	38·3	36·9	30·9	13·9	6	0

Chapter III. deals with the conditions of equilibrium in a system of three bodies, the particular substances studied being picric acid, β-naphthol and benzene, and a method of representing the experimental results by a three-dimensional model being explained. In Chapter IV. is considered the application of the law of mass action to the study of equilibrium in a triple system. Chapter V. is devoted to a consideration of the effect of a solvent on the progress of a reaction, and contains a simultaneous application of the law of mass action and the phase rule to this problem. A. H.

236. *Melting-Points of Mixtures of Optical Antipodes.* **M. Centnerszwer.** (Zeitschr. Phys. Chem. 29. pp. 715–725, September 15, 1899.)—The author has investigated the following series of mixtures:—d- and i- dimethyl tartrate; l- and i- methyl mandelate; d- and l- tartaric acid; l- and i- isobutyl mandelate; l- and i- mandelic acid; d- and l- chlorsuccinic acid; d- and l-camphoric acid; d- and i- chlorsuccinic; d- and l- isocamphoric acid; d- and l- benzyl-aminosuccinate; d- and l- aminosuccinic acid; d- chlorsuccinic and l- bromsuccinic acids; i- chlorsuccinic and l- bromsuccinic acids. In all except two cases the "normal" results are obtained, *i.e.*, when melting-point as ordinate is plotted against composition as abscissa, the curves show one maximum and two *break-minima*. This means that in these cases racemic compounds are stable under the conditions of the experiment and no solid solutions are formed. In two cases a different behaviour was observed. The curves for the two mixtures, d- and i- dimethyl tartrate, d- and l- tartaric acid, show no minima and one *break-maximum*. This indicates the presence of a racemic compound and two series of solid solutions in each case. F. G. D.

237. *Alloys of Platinum and Palladium with Cadmium, Zinc, and Magnesium.* **Hodgkinson, Waring,** and **Desborough.** (Chem. News, 80. p. 185, October 20, 1899. Paper read before the British Association, 1899.) —The more volatile metals were brought in contact with the platinum or palladium in the form of vapour. Platinum gave $PtCd_2$ as a white, crystalline, very brittle substance which does not lose weight when heated to redness *in vacuo*. With zinc, the alloy contained 45 per cent. of Zn, much of which volatilised at a red heat *in vacuo*, leaving PtZn (24·45 per cent. Zn) as a crystalline, very brittle mass. Magnesium gives a friable, crystalline alloy, approximating to the formula $PtMg_2$. Palladium shows practically no tendency to take up either cadmium or zinc vapour. Nickel behaves similarly. T. E.

238. *Fifth Report to the Alloys Research Committee.* **W. C. Roberts-Austen.** (Instit. Mech. Engin., Proc. 1. pp. 35–68. Discussion, pp. 68–102, February, 1899.)—In the present experiments a new differential recording pyrometer is used to study the phenomena of recalescence in the cooling of iron. Two galvanometers are used, one of the sensitiveness hitherto employed, the other much more sensitive. The platinum-iridium wire of the thermal junction, which is inserted as usual in the iron under examination, passes through a bored platinum cylinder in close proximity to, and therefore at the same temperature initially, as the iron. A second junction with the platin-iridium is made within the mass of platinum, and the thermal current here generated is opposed to the equal and opposite current from the first couple. The sensitive galvanometer is so connected that it fails to indicate so long as these opposing currents are equal, but as soon as recalescence occurs in the iron the equilibrium is destroyed and a reading is obtained

of the rise of temperature independent of the actual temperature at which it occurs. This latter reading is obtained from the less sensitive galvanometer, which traces the record of the cooling of the whole mass. Electro deposited iron examined with this arrangement showed recalescence points at 1,132° C., at 895° C. (the Ar_3 of Osmond), and at 766° C. (Ar_2). The Ar_1 point, as expected, was absent, there being no carbon present; but evidence of heat-evolution was obtained at a point between 550° and 600° C., again between 450° and 500° C., and yet again at 261° C. (slight). It is suggested that the 487° point represents the separation of a hydride of iron from solid solution in the mass of iron, and the 261° point the corresponding eutectic point, as both points are nearly obliterated after the iron has been repeatedly heated *in vacuo*, and are restored by recharging it with hydrogen by making it the negative electrode in acidulated water. The greater portion of the remainder of the report is devoted to the production of evidence in favour of carburised iron being a solid solution, the analogy of cryohydrates, and the evidence of the mechanical properties of various steels and of the microscope being dwelt upon. The application of photo-micrography to the examination of iron and steel from the scientific and technical points of view is described, and a large number of micro-photographs illustrating the structure of the metal are given in the paper, and by some of those taking part in the discussion. W. G. M.

239. *Disintegration of Platinum and Palladium Wires.* **W. Stewart.** (Phil. Mag. 48. pp. 481–484, November, 1899.)—That incandescent wires are gradually disintegrated has been proved, among other methods, by Lodge's experiment which shows that air freed from dust recovers its cloud-forming capacity after glowing a wire in it. In hydrogen such a wire does not disintegrate. Nahrwold supposed that oxygen is required for the disintegration of platinum or palladium. The author has confirmed this by a number of experiments made at various pressures, and has incidentally found that the disintegration decreases as the glowing is continued. Thus, in one set of experiments the same platinum wire was used six times consecutively, each experiment lasting two hours and the temperature of the wire being the same in each. The loss of weight gradually decreased from 0·68 per cent. to 0·11 per cent. of the weight. For palladium the same rule was found to hold good. The amount of disintegration was the same whether the air was moist or dry. On exhausting the space in which the wires glowed, the disintegration of platinum decreased, while that of palladium increased. We have therefore not to deal with an ordinary process of combustion, though Kaufmann has shown that disintegration is more rapid in pure oxygen. The actual process going on cannot as yet be said to be very clear. E. E. F.

240. *Electrical Determination of Saturation-point of Solutions.* **H. M. Dawson** and **P. Williams.** (Zeitschr. Elektrochem. 6. pp. 141–144, August 31, 1899.)—The method has already been described by J. H. van't Hoff. (See 1899, Abstract No. 1937.) In this paper the results of experiments on Glauber salts and sodium sulphate are given. The temperature-specific conductivity curves of saturated solutions of these two salts are almost parallel straight lines in the regions where the respective solutions are stable, but at about 30° C., where the transformation begins to take place, the curve for Glauber salts bends over towards the temperature axis and cuts the sodium sulphate straight line at about 32·6° C. Similar experiments are described with thorium sulphate in place of sodium sulphate. With the

thorium salts the amount of salt in concentrated solutions is much less than with the sodium salts. The curves obtained are approximately straight lines inclined to each other at about 90° and intersecting at the temperature 48° C. This transition temperature was tested also by the dilatometer, which gave 46·5° C. A tensimeter method, in which the point of equality of vapour pressures of the dry salt and its saturated solution is determined, gave between 47° and 48° C. J. B. H.

241. *Energy of Carbon and Voltaic Action.* **C. J. Reed.** (Elect. World and Engineer, 34. pp. 231–233, August 12th; 271–273, August 19th; 308–309, August 26th; and 342–343, September 2nd, 1899.)—After enunciating fundamental principles of voltaic action, the author considers the possibility of voltaically oxidising carbon by means of oxides, and thus converting its energy *directly* into electric energy. From thermal considerations it appears that only a few oxides are available, and of these the oxides of copper, bismuth, nitrogen, and sulphur are the only ones which are found in nature, and are wholly reducible. None of these, however, are capable of competing with the steam engine on account of their cost. Oxides which are partially reducible are likewise unavailable. The author then discusses indirect methods. The problem is not to find a solvent for carbon, but to find a process by which carbon may transfer its energy to a suitable substance from which the energy may be subsequently liberated voltaically. Such a process takes place in every primary battery, but the efficiency is much too low to compete with the steam engine. Several such efficiencies are calculated. W. R. C.

242. *Theory of Lead Accumulators.* **M. Mugdan.** (Zeitschr. Elektrochem. 6. pp. 309–320, December 7, 1899.)—Although the theory of the lead accumulator as a reversible element is pretty firmly established, there is general confusion with regard to the chemical processes taking place in the cell, and the views of Darrieus (see 1898, Abstract No. 1356), which are irreconcilable with the theory, are still accepted by many. According to this investigator, the PbO_2 of the positive plate is reduced to PbO during the discharge, whilst lead suboxide is formed at the negative plate, and the production of lead sulphate is regarded as due to secondary reactions; the peroxide produced in charging is held to be the result of the oxidation of the sulphate by persulphuric acid. The experiments described in the present paper were undertaken with the view of reconciling the physical and chemical investigations of the action of the cell. Contrary to the views of Darrieus, it is found that even with high current densities, rapid discharges, and dilute electrolytes, *i.e.*, under conditions least favourable to sulphating, lead sulphate, and at most only very trifling quantities of oxide, is formed on both plates. In short, lead, lead peroxide, and lead sulphate are the only substances concerned in the discharge of the accumulator.

By means of analyses before and after discharging in circuit with a copper voltameter, it is shown that with 10 per cent. sulphuric acid, a current density of 0·02 amperes per square centimetre, and a discharge lasting twenty minutes, lead sulphate is formed on both plates in practically the theoretical amount. When sodium sulphate solution is substituted for sulphuric acid, oxide is formed at the positive plate, but sulphate to the extent of 70 per cent. of the theoretical amount is produced at the negative electrode. In a second series of experiments the plates were discharged in normal sulphuric acid, thoroughly washed, digested with a known quantity of normal acid, and the amount of acid absorbed subsequently determined by titration. The results show no evidence of the production of oxide, except at the positive plate when sodium sulphate was used instead of acid in the discharge, and are in full agreement with the view that sulphating is a primary, and not merely a secondary process. These results are confirmed by experimental determinations of the curves of anodic and kathodic polarisation, of which diagrams are given. It is also shown that persulphuric acid, which is formed in trifling quantity in charging under normal conditions, exerts no oxidising action on lead sulphate, as required by Darrieus's theory; on the contrary, it deoxidises lead peroxide.

Experimental confirmation is adduced of Dolezalek's theory that the E.M.F. of the accumulator depends only on the concentration of the electrolyte, and it is pointed out that the changes in the E.M.F. during charging and discharging are due to variations in the resistance of the cell brought about by the influence of sulphating and local variations in the concentration of the electrolyte. The influence of acid concentration on the E.M.F. of the electrodes taken separately is finally discussed, and the theoretical deductions shown to be in accordance with experiment. N. L.

243. *Paraanisaldoximes.* **H. R. Carveth.** (Journ. Phys. Chem. 3. pp. 437–451, October, 1899.)—α-Paraanisaldoxime melts at once at 62·8°, and in 55 minutes at 61·0°, but does not melt at 58·9° in 135 minutes. β-Paraanisaldoxime melts in 30 seconds at 134°, in 155 seconds at 124·5°, in 6 minutes at 117·1°, and in 2 hours at 89·5°. This variation in melting-point is due to the fact that both isomerides undergo isomeric change, and pass in the fused state to a condition of equilibrium. The stable triple-point at which the solid α-oxime is in stable-equilibrium with the fused mixture is 54·20°; the entectic-point lies about 0·2° lower and represents the freezing-point of a mixture containing a slight excess of the β-oxime as compared with the normal state of equilibrium in the fused mixture.

The addition of hydrochloric acid converts both oximes completely into the hydrochloride of the β-oxime. The reconversion of the β-oxime into the stable α-oxime takes place gradually by heating it either alone or with a solvent, and is indicated by the lowering of the melting-point; this falls to 118° by heating with alcohol at 100° for an hour, and to 86° by heating for 2½ hours; 3 hours' boiling with toluene lowers the melting-point to 111°, 70 minutes' boiling with toluene to 127°, and 2 hours' boiling with acetone to 62°. As the isomeric change takes place most rapidly in acetone and least rapidly in toluene, the latter is the best solvent to use for recrystallising the β-oxime. T. M. L.

244. *Dissociation of Gases.* **R. Wegscheider.** (Akad. Wiss. Wien., S.ber. 108. pp. 69–81, 1899.)—Under constant external pressure and at a uniform temperature the proportionate number of gramme-molecules dissociated is, when there is an infinite dilution with one of the products of dissociation, the square of what it is when there is no such dilution; that is, when the products of dissociation are two in number. For intermediate conditions the proportion dissociated is intermediate; and no amount of dilution with one of the products will altogether prevent dissociation from taking place. If the dissociation-reaction be that n_0 gramme-molecules break up into n_1, n_2, . . . &c., gramme-molecules, there are three cases; (1) $n_0 - (n_2 + n_3 + \&c.) < 0$, where n_1, the missing n, is that corresponding to the product of which an excess is added: in this case the dissociation, at infinite dilution with the product of dissociation, is complete; (2) $n_0-(n_2+\&c.)=0$, in which case the proportion between the dissociated and undissociated at infinite dilution with one product is—

$$\sqrt[n_0]{\left\{\left(\frac{n_1}{n_0}\right)^{n_1}\cdot\frac{a^{n_1+n_2+\&c.}}{\left(1+\frac{n_1}{n_0}a\right)^{n_1}\left(1-a\right)^{n_0}}\right\}}$$

where a is the proportion dissociated when there is no dilution; and (3) $n_0-(n_2+\&c.)>0$, in which case an excess of a product completely checks dissociation. Examples of these three cases: (1) [not given: *qy.* ammonia gas diluted with nitrogen?]; (2) carbonic acid diluted with oxygen: $2\,CO_2=O_2+2\,CO$; $n_0=2, n_2=2$; $n_0-n_2=O$; the dissociation has a definite value at all dilutions with oxygen; hence no excess of oxygen will enable carbonic oxide to become thoroughly burned into carbonic acid; and where the proportions dissociated without dilution with oxygen were 0·01, 0·1, 0·3, 0·5, 0·7, 0·9, respectively, the corresponding dissociations at infinite dilutions with oxygen would be 0·0007, 0·024, 0·134, 0·309, 0·543, and 0·834, so that the restraining effect of the addition of oxygen rapidly falls off as the original tendency to dissociation increases; (3) carbonic acid diluted with carbonic oxide: $2\,CO_2=2\,CO+O_2$: $n_0=2, n_2=1$; $n_0-n_2>O$; a considerable excess of carbonic oxide will completely prevent dissociation. Under constant volume on the other hand, an excess of one of the products will restrain, and an infinite excess will completely prevent dissociation. When a reaction in a dilute solution is associated with a change in the osmotic pressure, there is on further dilution a change in the equilibrium such as tends to increase the osmotic pressure, and thus acts in a sense opposed to the dilution. The presence of phosphorus trichloride does not completely prevent the dissociation of phosphorus pentachloride: some 3 to 10 per cent was dissociated in Wurtz's experiments. A. D.

245. *Uranyl Salts.* **C. Dittrich.** (Zeitschr. Phys. Chem. 29. pp. 449–490, 1899.)—The electrolytic conductivity and freezing-points of solutions of a number of uranyl salts and of mixtures of uranyl and sodium salts are measured, also the solubility of uranyl oxalate in sodium oxalate solution and some thermochemical data. Qualitative experiments show that the uranium migrates to the anode when solutions of sodium uranyl acetate (concentrated), propionate, oxalate, tartrate and citrate are electrolysed. It is shown that in these cases complex anions containing the UO_2 radicle are formed. In most uranyl salts UO_2 is the kathion. The details are mainly of chemical interest. T. E.

246. *Liquid Mixtures with Minimum Boiling-points.* **J. H. Pettit.** (Journ. Phys. Chem. 3. pp. 349–363, 1899.)—The following statement is submitted to experimental examination: If the vapour-pressure curves of two liquids which are miscible in all proportions intersect, then some mixture of the liquids has a maximum or minimum boiling-point. Mixtures of chloroform and methyl alcohol have a minimum boiling-point at about 90 per cent. of chloroform, mixtures of acetone and methyl alcohol have a minimum at 86·5 per cent. of acetone, mixtures of ether and methyl alcohol have neither a minimum nor a maximum boiling-point. In the two first cases the vapour-pressure curves intersect; in the last case they do not. Fourteen other cases of minimum boiling-points are collected from existing sources, and where vapour-pressure curves are available they are shown to follow the

rule. The converse is also true as far as data are available. The composition of the vapour evolved from mixtures of acetone and methyl alcohol is determined, and the application of the results to the practice of fractional distillation pointed out. T. E.

247. *Chemical Equilibrium and E.M.F.* **H. Danneel.** (Zeitschr. Elektrochem. 6. pp. 293–295, November 23, 1899.)—The author considers the reaction, $M_1+M_2X \rightleftarrows M_1X+M_2$ where one metal partially displaces another equi-valent metal from a solution of one of its salts. Regarding the dissociations as complete, the equilibrium may be written: $M_1+\overset{+}{M}_2=\overset{+}{M}_1+M_2$. By a somewhat roundabout method the author arrives at the following result (*cf.* Nernst and Ogg): The ratio of the solution-tensions of the two metals is equal to the corresponding ionic concentrations when equilibrium is attained in the above reaction.

Putting $M_1=Ag$, $M_2=H$ and $HX=HI$, we have $Ag+\overset{+}{H}=\overset{+}{Ag}+H$, and—

$$\frac{P_H}{P_{Ag}}=\frac{[\overset{+}{H}]_0}{[\overset{+}{Ag}]_0}$$

where the P's denote solution-tensions and the suffixes 0 indicate equilibrium-values of the ionic concentrations. Considering AgI to be completely dissociated in solution, and putting its solubility in mols.$=a$, we have *for any* solution with solid AgI present, $[\overset{+}{Ag}]\,[\overset{-}{I}]=a^2$. In a solution containing any appreciable quantity of HI we may put $[\overset{+}{H}]=[\overset{-}{I}]$, and so we get finally—

$$[\overset{+}{Ag}]_0=\frac{a^2}{[\overset{+}{H}]_0}$$

and therefore—

$$\frac{P_H}{P_{Ag}}=\frac{[\overset{+}{H}]_0^2}{a^2}.$$

The author obtains the value of $\frac{P_H}{P_{Ag}}$ from the known E.M.F. of a silver-hydrogen cell in which the ionic concentrations of silver and hydrogen are equal, and the value of a^2 from the solubility-measurements of Specketer and Goodwin. In this way he calculates $[\overset{+}{H}]_0=0{\cdot}057$ at 18° C. His own actual determination of $[\overset{+}{H}]_0$ gave 0·042 at 13° C. In view of the difference in temperature, and the uncertainty of the solubility-data for AgI, the agreement is regarded by the author as satisfactory. F. G. D.

248. *Electrolytic Potential and its Application.* **A. Schükarew.** (Zeitschr. Phys. Chem. 29. pp. 726–729, September 15, 1899.)—The author introduces into the theory of conducting solutions a function ϕ, the "electrolytic potential," defined by the equation:—

$$\phi=\left(\frac{\delta U}{\delta \lambda}\right)_{T,S,p,v,m,\ldots,\mu\ldots}$$

Where $U=$ inner energy of system, $\lambda=$ its electrolytic conductivity, T temperature, $S=$ entropy, $p=$ pressure, $v=$ volume, $m=$ mass of a component,

μ = Gibbsian chemical potential of a component. Following Gibbs's thermodynamical method the author then proceeds to deduce the "dilution-formula :—

$$\frac{\text{Log}\,v_0 - \text{Log}\,v}{\text{Log}\,\lambda_0 - \text{Log}\,\lambda} = \kappa$$

which he shows to hold well for solutions of acetic acid.

[It is necessary to remark, however, that the author's theory contains the assumption $d\mu = \text{K}d\phi$, for which he gives no justification.] F. G. D.

249. *Conductivity of Aqueous Solutions of Potassium Magnesium Sulphate.* **T. C. McKay.** (Elektrochem. Ztschr. 6. pp. 111–115, September, 1899.)—A series of experiments was made to ascertain whether the conductivity of solutions of the double sulphate of potassium and magnesium could be calculated on the assumption that the salt is decomposed into potassium and magnesium sulphates by dissolution in water. With solutions of the double salt containing from 0·4 to 1 gramme—equivalent per litre the conductivity is less than that calculated for the separate salts, but with more dilute solutions the reverse is the case, although the differences are small. It is concluded that in dilute solutions the double sulphate suffers decomposition, but that in strong solutions the two constituents remain united. N. L.

250. *Conductivity of Aqueous Solutions of Alkali Chlorides and Nitrates.* **F. Kohlrausch** and **M. E. Maltby.** (Preuss. Akad. Wiss. Berlin, S. ber. 36. pp. 665–671, July 20, 1899.)—The authors seek to attain a higher degree of accuracy than has yet been reached, especially with the more dilute solutions, by using reliable electrical standards and thermometers, by special care in the manipulation of the electrical measurements, by employing salts and water, purified with unusual care, and by paying great attention to the accurate determination of the concentration of the solutions.

The new determinations give numbers which are somewhat smaller than those previously accepted as the most accurate, especially in the most dilute solutions where differences of ½ to 2½ per cent. are found.

The results show that up to and including the concentration 0·002 gram. mol. per litre, the law of independently mobile ions is exactly true ; in more concentrated solutions this is not the case. The diminution of the equivalent conductivity with increasing concentration is roughly proportional to the square root of the equivalent conductivity. T. E.

251. *Ionisation of Good Electrolytes.* **H. Euler.** (Zeitschr. Phys. Chem. 29. pp. 603–612, September 15, 1899.)—That salts do not follow Ostwald's dilution law may be due (*a*) to invalidity of the equation $a = \mu_v/\mu_\infty$; (*b*) to invalidity of the law of mass-action.

(*a*) The equation $a = \mu_v/\mu_\infty$ assumes that the mobility of the ions is independent of the concentration. The loss of mobility due to the greater viscosity of more concentrated solutions is too small to account for the differences observed. There is no reason to assume a hydration of the ions, increasing with dilution, which might affect the mobility, because the active mass of the water is practically constant in moderately dilute solutions. The electrostatic charges of the ions may possibly affect their mobility.

(*b*) The law of mass-action refers, strictly, to the osmotic pressures of the reacting substances and not to their concentrations. It is very possible that the osmotic pressure of an ionised substance is smaller than that which would correspond to its concentration. An attempt to test this view failed. If the ionising power of a solvent increases with the number of ions in solution owing to increased polymerisation (see 1899, Abstract No. 1940), the effect should decrease as the temperature rises, and Ostwald's law should be more nearly true at high than at low temperatures. Measurements of the conductivity of KCl and $AgNO_3$ show that the precise opposite is the case. The author finally falls back on the assumption of a "change of the ionising power of the solvent by the dissolved salt." T. E.

252. *Ionisation of Sulphuric Acid.* **W. Starck.** (Zeitschr. Phys. Chem. 29. pp. 385–400, July 28, 1899.)—It is probable that sulphuric acid is dissociated, in aqueous solution, into the ions H, SO_4, and HSO_4, and that the relative quantity of the last increases with the concentration of the acid. If this is true, the migration constant for the anion (n), calculated on the assumption that SO_4 ions alone are formed, should increase with the concentration. Determinations of the migration constant in acids containing from 0·29 to over 81 per cent. of H_2SO_4 show that this is the case, the values of n increasing from about 0·2 to 0·64. The values of n also increase considerably with rising temperature.

Contrary to Bein's statement (see 1899, Abstract No. 1234), the values of n obtained in apparatus containing diaphragms of parchment paper or porous porcelain are smaller than those obtained in apparatus without a diaphragm. T. E.

253. *Calculation of Depression of Freezing-point.* **E. H. Archibald.** (Chem. News, 80. pp. 46–47, July 28th; 57–59, August 4th; 68–69, August 11th; and 76–77, August 18, 1899. Transactions of Nova Scotian Institute of Science, vol. 10, 1898–99.)—The object of the experiments was to test the values of ionisation coefficients obtained by J. G. MacGregor's graphical method in the case of a mixture of solutions of two electrolytes with a common ion, by employing them in the calculation of the depression of the freezing-point. Solutions of potassium and sodium sulphates were employed. In the conductivity determinations it was found that the temperature coefficient for potassium sulphate diminished with increase of dilution, the reverse being the case with sodium sulphate. The ionisation coefficient of potassium sulphate increases slightly with rise of temperature, but in the case of the sodium salt it diminishes. Depressions of freezing-point were measured by the method of Loomis, and results were obtained agreeing well with Loomis's. The observed and calculated values for the depression in the case of the simple solutions agreed closely. The calculations for the mixtures were made by the following formula, due to MacGregor:—

$$\Delta = 1{\cdot}86(1+a_1+a_2)N/2.$$

(a_1, a_2 are the ionisation coefficients and N the gr.-equivalents per litre.) The calculated and observed results showed an equally good agreement. W. R. C.

254. *Electrolytic Solution-pressure.* **R. A. Lehfeldt.** (Phil. Mag. 48. pp. 430–433, November, 1899. Paper read before the British Association September 20, 1899.)—The electromotive force between a metal and an electrolyte, as given in Nernst's well-known form, is—

$$E = \frac{RT}{\epsilon}\log_e\frac{\pi}{P}$$

The values obtained by Le Blanc for the electrolytic solution pressure π from the observed values of the E.M.Fs. vary from $9{\cdot}9\times10^{+18}$ atmospheres for zinc, to $1 \cdot 5 \times 10^{-36}$ atmospheres for palladium, numbers which it is difficult to accept as representing physical realities.

The author introduces another objection. If an electrical double layer is formed between the metal-plate and the ions in solution near it, a tension is set up between the two. The amount of this tension is $2\pi\sigma^2/D$, on the assumption that the electricity is distributed in two layers of equal surface density σ, D being the dielectric constant of the medium. Also $\sigma = \epsilon x$, where $x =$ number of gramme-equivalents of metal per square centimetre of surface which have gone into solution. Substituting, for the case of zinc ($D = 80$ for water) we get—

$$x = 1 \cdot 27 \text{ grammes},$$

which is obviously not the case. J. B. H.

255. *Photographic Study of Cells.* **R. R. Ramsey.** (Phys. Rev. 9. pp. 189–190, September, 1899.)—Töpler's *Schlierenapparat* may be used for the study of the actions within the electrolytic cell. Every change of density is indicated by a darkening or brightening of the field. The author reproduces some photographs obtained with the current passing up or down through the liquid. E. E. F.

256. *Luminous Phenomena in Electrolytic Cells.* **F. Eichberg** and **L. Kallir.** (Akad. Wiss. Wien., S. ber. 108. pp. 212–219, 1899.)—When alternating currents are passed between two aluminium or magnesium plate electrodes in dilute acid solutions, or solutions of some salts, a continuous luminous glow is seen all over both electrodes, slightly greater in intensity nearer the edges of the plates than at the centres. With continuous currents the phenomena are somewhat different. A clean aluminium plate as anode becomes luminous at the moment of making the current, but very quickly loses the luminosity. A similar plate as kathode does not become luminous. An aluminium plate which has been used as anode becomes luminous when used as kathode in very dilute acid or in water; but in stronger acid solutions, and in solutions of caustic potash, alum, and copper sulphate no luminosity is detected. When both electrodes become luminous the relative intensities depend on the concentration of the solution.

In order to find to what particular part of the period of the alternating current the luminosity is due, the electrodes were examined stroboscopically, the stroboscopic disc being driven by a motor running off the same alternating current mains. By this means each part of the electrode is only visible at one particular phase of the current. The alternate light and dark spaces then seen show that each electrode is lighted up once during each half period.
J. B. H.

257. *Electrolytic Evolution of Gases.* **W. A. Caspari.** (Zeitschr. Phys. Chem. 30. pp. 89–97, October 13, 1899.)—This investigation was undertaken with the view of determining the minimum E.M.F. at which gas bubbles are evolved in the electrolysis of acid solutions. The phenomena at the two electrodes are considered separately, the electrodes being in separate vessels A and B, connected by a capillary tube. The vessel A is similarly connected with a third vessel C, which contains a large electrode of platinised platinum, the part above the solution being surrounded by an atmosphere of hydrogen. The electrode in B is fixed and is a large plate of platinised platinum, while the electrode in A is altered in the different experiments and is of wire. The

E.M.F. is applied to A and B, and is increased until bubbles are seen on the electrode in A. The difference of potential between the A and C electrodes is then measured. Theoretically this should be zero when A is kathode, and 1·08 volts when A is anode. Owing to the evolution of gas it is always greater than these values, the excess E.M.F. varying with the metal of the A electrode, with several other conditions. A table of Caspari's results was given in the Abstract No. 1941 (1899). The general results of the experiments are :—

1. With platinised platinum electrodes in acid solution, a visible evolution of gas begins first of all with from 1·55 to 1·56 volts, at ordinary temperatures and pressures.

2. The evolution of hydrogen on platinised platinum is practically a reversible phenomenon, and the theoretical E.M.Fs. are obtained. Other metals require an *excess* E.M.F.

3. This *excess* E.M.F. is increased by great current density, but is little influenced by the nature of the surface of the electrodes.

4. The *excess* E.M.F. is the deciding factor in the chemical evolution of hydrogen from the interaction of metal and acid, making the evolution possible with some metals and not with others.

5. The deposition of bromine and of iodine on platinum fulfils the conditions of reversibility.

6. Silver is deposited from complex salts, also as a reversible phenomenon in spite of very low ion concentration. J. B. H.

258. *Velocities of Ions in Electrolysis.* **O. Masson.** (Zeitschr. Phys. Chem. 29. pp. 501–526, July 28, 1899.)—This paper starts with a review of the history of the subject, which the author divides into three parts : the Hittorf, the Kohlrausch, and the Lodge and Whetham parts. He criticises the several experimental methods adopted by these investigators, and also the application of their experimental results to the theory. He then describes his own method, and shows how in it all the factors in the general equation

$$C = A\frac{n}{\eta}(U + V) = A\frac{n}{\eta}\pi x(u + v)$$

are measurable, so that his experimental results should really test the theory, or rather should test the assumptions on which the theory is built.

He adopts Lodge's plan of making his electrolytes stiff with gelatine. A long straight tube is filled with the hot solution of electrolyte and gelatine, and the solution is allowed to cool and stiffen in the tube. Any solution projecting beyond the ends is then cut off. This tube is made to connect two large flask-shaped vessels through stoppered openings in their sides. Each of these vessels contains a large plate electrode, and the vessel containing the anode is filled with a solution having a coloured anion ($CuSO_4$), and the other is filled with a solution having a coloured kathion ($K_2CrO_4 + K_2Cr_2O_7$).

The current circuit is made, and a time record taken of (1) the current, (2) the E.M.F. between the electrodes, (3) the progress of the coloured kathion along the tube, (4) the progress of the coloured anion along the tube. It should be stated that these coloured ions should be so chosen that their velocities are less than those of the corresponding ions in the electrolyte in the tube, otherwise the advance of the coloured ions will not be sharply defined. The advance of the colour is taken by means of graduations on the tube. An experiment was finished when the two colours met. The ratio of the lengths of the coloured columns is constant and gives the ratio u/v for that particular concentration, while the rates of growth of these coloured columns give the actual values of U and V for the particular potential gradient. Since the uncoloured part of the electrolyte in the tube remains always of the same concentration and of the same specific resistance (since the temperature is kept constant), the falling off in the current must be due to the increase of resistance of the coloured parts. The potential gradient in the uncoloured part must be proportional to its length and to the current; and its actual value can be obtained from one measurement of the resistance.

The results of experiments with a number of different electrolytes are given in tabular form in the paper, and are applied to test the above equation with fairly satisfactory results, the greatest discrepancy being with $MgSO_4$, which gives with different concentrations the ratios between the two sides of the equation as from 0·942 to 0·807 instead of unity. The variations in this ratio with the other salts experimented with, are from 3 per cent. above unity to 5 per cent. below. J. B. H.

259. *Action of Electric Currents upon Ferments.* **F. J. Möller.** (Ind. Électrochim. 3. pp. 63-64, 1899, from "Revue de Chimie Industrielle," p. 169, 1899.)—The author gives brief notes relating to the work of Hermite, Oppermann, Prochownik, Hall, Sommer, Schwartz, Burri, Foth, d'Arsonval and Charrin, Kruger, Spilker and Gottstein, and of himself in connection with the investigation of this subject.

He then describes some investigations by Duclaux upon vinous fermentation, and states that this chemist has found that alternating currents of low E.M.F. can be used to hinder the development of objectionable or foreign ferments in the "must" or "wort." This method is in actual operation in an Austrian alcohol factory. Aluminium electrodes are used, with an alternating current of 0·10 to 0·20 amperes per square decimeter, and an E.M.F. of only 3 volts. Continuous currents may be used; but in this case thermal and chemical effects are also obtained at the electrodes, which are not conducive to the attainment of the desired results. J. B. C. K.

260. *Action at the Aluminium Anode.* **K. Norden.** (Zeitschr. Elektrochem. 6. pp. 159-167, September 7th, and 188-202, September 14, 1899.)—This paper, a great part of which is mainly of chemical interest, is described as a contribution to the electrolytic transformation of alternate into direct currents (Compare 1898, Abstracts Nos. 207, 1358), and the first part consists of a critical and historial account of the researches of Woehler, Buff, Beetz, Graetz, Pollak, Wilson, and others, on the abnormal behaviour of the aluminium anode. The second part is devoted to an exhaustive quantitative study of the cell, and full details of the electrical measurements and chemical analyses are given in the paper. The film which forms on the surface of the anode is shown to be a mixture of aluminium hydroxide and basic sulphate with a little silica and metallic aluminium; it plays an important part in the action of the cell, which is considered to take place thus. The oxygen resulting from the secondary decomposition of the sulphuric acid forms, with the co-operation of the water of the electrolyte, a layer of aluminium hydroxide on the anode. This is at first attacked by the sulphuric acid and enters into simple, chemical solution; the aluminium sulphate thus formed round the anode reacts with the hydroxide thereon and converts it into basic sulphate, which is again transformed into the normal sulphate by the sulphuric acid of the electrolyte. At those parts of the anode where the metal is exposed through solution of the layer of hydroxide the oxygen atoms give up their charge and either escape in the gaseous state or are employed in forming new layers of hydroxide which are then acted on as previously described. The hydroxide which enters into simple chemical solution is nevertheless to be considered in reckoning the work done by the current, since its formation from the aluminium is brought about by the oxidising action of the current. The transmission of the current by the cell is unintelligible if the anode film be regarded as insoluble, and in the case of electrolytes, such as neutral salts, which are less favourable to the solution of the basic salt the resistance to the current is much increased. Hence the use of neutral or alkaline solutions, as suggested by Pollak, is more advantageous for the rectification of alternate currents than that of dilute sulphuric acid.

N. L.

261. *Disintegration of Metallic Kathodes.* **G. Bredig** and **F. Haber.** (Ind. Électrochim. 3. p. 75, July, 1899, from Bull. Soc. Chim. 3. 12. p. 257.)—An anode of platinum and a kathode of lead, the latter consisting of thread freshly cut and only touching the surface of the electrolyte (40 per cent. sulphuric acid) with an E.M.F. of about 24 volts, cause a disintegration of the lead which diffuses round the kathode. By breaking and making, this phenomena is maintained, which otherwise ceases to manifest itself. The more dilute the acid and the greater the E.M.F. employed, the more marked is the effect, resulting in local fusion of the kathode on the surface. $Cr_2O_7K_2$ in small quantities, however, obviates this result. With the employment of a caustic electrolyte this disintegration is still more marked. The lead thus precipitated is extremely active, and by the employment of a solution of K_2CO_3 and gassing with CO_2, white lead is formed; but the cost of production would prevent the commercial application of this method.

Other metals disintegrated in alkaline solutions are Hg, Th, Bi, As, Sb, whereas Zn, and Cd, and the other more infusible metals do not show this reaction. In an acid solution only Bi and Pb are affected in this manner.

The authors explain this phenomenon by the formation of metallic hydrides and their fusibility, and in the case of lead by the lesser or greater displacement of the metallic kathode surfaces previously investigated by Haber. The disintegration is not accompanied by luminous effects and is therefore unlike the arc, the discharge in Geissler tubes and the incandescence of metallic filaments. O. J. S.

262. *Nature of Zinc Sponge.* **F. Foerster** and **O. Günther.** (Zeitschr. Elektrochem. 6. pp. 301–303, November 30, 1899.)—In a former paper (see 1899, Abstract No. 151) the authors expressed their opinion that the production of zinc sponge is due to disturbance of the crystallisation of the metal at the kathode by the separation of zinc hydroxide or of basic zinc salts. It was therefore expected that the use of alkaline solutions, in which zinc hydroxide is readily soluble, would obviate the production of spongy zinc, and the first experiments in this direction seemed to show that this was the case. Further experiments have shown, however, that although fine, coherent deposits are at first obtained by the electrolysis of solutions of zinc oxide in caustic soda, yet after a short time, usually less than an hour, the formation of a spongy deposit is observed, especially when the agitation of the liquid is insufficient. Variation of the temperature from 20° to 50°, or of the current density from 0·02 to 0·09 amperes per square centimetre, has little influence on the results. The zinc sponge is formed more rapidly and more abundantly in dilute than in strong solutions. Similar results were obtained with alkaline lead solutions, but no sponge appears to be formed if ammonia, instead of potash or soda, is used in the electrolysis of solutions of zinc and cadmium.

These results show that the views previously expressed require modification, but it may be stated generally that the production of zinc sponge is associated with the liberation of hydroxyl ions and a proportionately small concentration of zinc ions. N. L.

263. *Electrolytic Baths.* **Q. Marino.** (Elektrochem. Ztschr. 6. pp. 97–99, August, 1899.)—The use of glycerin instead of water as a solvent in electrolytic processes is attended with great advantages. This liquid is neutral, miscible in all proportions with water and alcohol, and dissolves most substances which are soluble in water; it opposes little resistance to the migration of the ions, and wasteful secondary reactions are obviated by its employment. Various illustrations are given of the general availability of glycerin in electrolysis. N. L.

264. *Dissolution of Iron Anodes in Sodium Acetate and Acetic Acid.* **G. Arth.** (Ind. Électrochim. 3. pp. 83–84, August, 1899; Bull. Soc. Chim. 21–22. p. 766.) —A number of experiments were made on the electrolysis of an aqueous solution containing 5 per cent. of sodium acetate and 5 per cent. of acetic acid, the kathode being a platinum cylinder and the anode a pure iron plate 50 mm. long, 12–15 mm. broad, and about 2 mm. thick. Using a current of 0·10–0·36 amperes at 0·79–1·35 volts, the iron dissolves as *ferrous* acetate in an amount corresponding with that required by Faraday's law, whilst at higher voltages and under conditions which are yet undetermined the theoretical quantity of *ferric* acetate is formed. In some experiments, moreover, the iron was observed to assume an almost "passive" condition, only a small quantity of ferric acetate being formed. In connection with these results some observations of Wohlwill (see 1898, Abstract No. 684) on univalent and tervalent gold ions are referred to. (Similar results in the case of chromium have been obtained by W. Hittorf. See 1898, Abstract No. 1,072, and 1899, Abstract No. 1744.) N. L.

265. *Electrolytic Reduction of Nitro-derivatives.* **P. Pierron.** (Ind. Électrochim. 3. pp. 84–86, August, 1899; Bull. Soc. Chim. 21–22, p. 780, 1899.) —The nitro compound is dissolved in a mixture of alcohol and sulphuric acid, and electrolysed between a platinum anode and nickel kathode, using a kathodic current density of 0·4–0·75 amperes per square decimetre. At the ordinary temperature the nitro-derivatives of the paraffin hydrocarbons yield substituted hydroxylamines, but at 70° C. further reduction occurs, and the corresponding amines are principally formed. N. L.

266. *Reducing Action of Electrolytically separated Metals.* **A. Binz** and **A. Hagenbach.** (Zeitschr. Elektrochem. 6. pp. 261–271, November 2, 1899. Read before the 71st Meeting Deutscher Naturforscher und Aerzte zu München.)—The reducing action of metals in the presence of water is commonly attributed to the nascent hydrogen evolved therefrom, but it is well known that the effect produced depends on the source of the hydrogen, that is, on the metal from which it is evolved or at which it is liberated in electrolysis. Various explanations of this fact have been suggested, and the present paper, much of which is of chemical interest only, commences with a brief historical account of these. Former investigations (see 1899, Abstracts

Nos. 153 and 154) on the electrolytic reduction of indigo having indicated that the zinc used as the anode played an important part in the reaction, further experiments on the electrolytic reduction of indigo and other organic colouring matters in alkaline solution have been made with the following results. The results previously obtained with indigo are confirmed. The ease with which the colouring matters are reduced by sodium and potassium amalgams increases as the quantity of hydrogen evolved therefrom decreases, and the reduction is not effected to the same extent by the equivalent quantity of hydrogen, the difference being greatest when the hydrogen is electrolytically evolved at a low current density. Zinc, when deposited on a mercury kathode from its solution in caustic alkali, reduces more quickly than an equivalent amount of hydrogen at a low current density. Reduction is also effected by zinc and lead when these metals are deposited on a mercury kathode from solutions of their acetates. These results lead to the conclusion that the colouring matters investigated, although reduced by nascent hydrogen, are much more quickly reduced by the direct action of sodium, potassium, and zinc. N. L.

267. *Electrolysis of the Bromides of the Alkaline Earth Metals.* **J. Sarghel.** (Zeitschr. Elektrochem. 6. pp. 149–158, September 7; and 173–188, September 14, 1899.)—In this paper a detailed account is given of a large number of experiments on the electrolysis of aqueous solutions of the bromides of calcium, magnesium, and barium. The electrolysis was carried out between platinum electrodes in a closed cell, without a diaphragm, placed in a bath of constant temperature, and provided with arrangements for the collection of the gases evolved; the bromine existing as bromate and hypobromite was determined by analysis after each experiment, the electrolysis being continued in every case until the yield became sensibly constant. The influence of variations in concentration, in temperature, and in the current density and E.M.F. was also studied. As regards calcium bromide the final yield of available bromine increases with the temperature until a certain limit is reached which lies at about 90° for 10 per cent., and at a somewhat lower temperature for 20 per cent. solutions. Above these limits the yield decreases, on account of increased reduction. With low current densities the yield is smaller in concentrated than in dilute solutions; high current densities favour reduction and the formation of hypobromite. The reduction is decreased by raising the current density at the kathode, but increased by raising it at the anode. Addition of free alkali (lime) favours reduction and formation of hypobromite, and consequently lowers the yield. The condition of the kathode is an important factor in the electrolysis. A rough surface favours the production of bromate since the lime deposited adheres to the kathode; whilst a smooth surface is advantageous to the formation of hypobromite, because the lime is not deposited on the kathode but remains suspended in the liquid, and therefore produces the same effect as the addition of free alkali. The yield of bromate is greater with calcium than with potassium, bromide, and the course of electrolysis is essentially different, as was to be expected from the comparative insolubility of lime.

In the case of magnesium bromide a larger amount of hypobromite and a smaller amount of bromate is formed than is the case with calcium bromide, and the final yield is notably less. This was found to be due to the escape of bromine, since the solution does not contain enough of the very sparingly soluble magnesium hydroxide to combine therewith. A rise of temperature favours the production of bromate, and thus increases the yield. Contrary to what is observed with calcium bromide, high current densities, up to a certain point, decrease the reduction and decomposition of water, and therefore increase the yield. The same effect is produced by increased current density at the anode or kathode alone. Addition of alkali increases the yield by preventing escape of bromine; a large excess, however, decreases the yield.

With barium bromide, owing to the greater solubility of barium hydroxide, a lower yield is obtained than with calcium and magnesium bromides. As with potassium bromide, the yield is decreased by a rise of temperature.

N. L.

268. *Electrolysis of the Alkali-Metal Chloride Solutions.* **H. Wohlwill.** (Zeitschr. Elektrochem. 6. pp. 227–230, October 5, 1899.)—This contribution to the theory of the electrolytic chlorate cell must be read in conjunction with previous contributions by Wohlwill (see 1899, Abstract No. 341), and by Foerster (see 1899, Abstract No. 1946) on the same subject.

The correctness of the "ionic equation" given by Wohlwill in the former when applied to the formation of chlorate in neutral or slightly acid solutions, has been disputed by Foerster. Foerster maintains that in such solutions the chlorate is the result of a secondary reaction between free hypochlorous acid and $\overline{\mathrm{ClO}}$ ions. Wohlwill now replies to this by quoting the results of experiments which, in his opinion, prove that $\overline{\mathrm{OH}}$ ions may be formed in both neutral and slightly acid solutions; and by showing that in such solutions it is probable that both primary and secondary reactions occur during the formation of chlorate. J. B. C. K.

269. *Electrolysis of the Alkali-Metal Chloride Solutions.* **F. Foerster.** (Zeitschr. Elektrochem. 6. pp. 253–256, October 26, 1899.)—This contribution is a reply to that of Wohlwill (see preceding Abstract). In this latest contribution to the discussion, Foerster maintains the correctness of his criticism of Wohlwill's theory of the chlorate cell, and reasserts his opinion that in neutral or slightly acid solutions, the formation of chlorate is chiefly due to secondary (chemical) and not to primary (ionic) reactions. J. B. C. K.

270. *Electrolysis of Ammonium Thiosulphate.* **P. Pierron.** (Chem. News, 80. pp. 73–74, August 18, 1899; from Bull. Soc. Chim. 3. 21. No. 10.)—The aqueous solution of ammonium thiosulphate, containing 17·5 per cent. of the anhydrous salt, was placed in a porous pot in which a cylindrical platinum electrode was suspended; the other electrode, of lead, surrounded the porous pot and was placed in a 10 per cent. ammonium carbonate solution. The temperature was maintained at about 15° throughout the experiments. In the first experiments, the platinum was used as the kathode and a current density of 10 to 40 amperes per square decimetre was employed. Under these conditions reduction occurs, and ammonium sulphide appears to be the sole product. If the inner electrode is the anode the reactions are much more complex; sulphur is deposited, sulphurous anhydride is given off, and the liquid becomes acid from the formation of sulphuric, trithionic, and tetrathionic acids. Small quantities of pentathionic acid are formed in the early stages but are subsequently destroyed by oxidation; hydrogen sulphide was not detected. The formation of free sulphur and sulphuric acid increases with the anodic current density (3–40 amperes per square decimetre), whilst the amount of tetrathionic acid decreases; little variation is noticed in the sulphurous and trithionic acids. In explanation of these facts it is suggested that the $SO_3.S.NH_4$ ions first formed split up into sulphur, sulphuric acid, and

ammonium sulphate. The latter then itself undergoes electrolysis, forming sulphuric acid and oxygen, which converts a portion of the thiosulphate into tetrathionate. N. L.

271. *Electrolysis of Solid and Melted Electrolytes.* **C. C. Garrard.** (Zeitschr. Elektrochem. 6. pp. 214–216, September 28, 1899.)—The object of these experiments was to determine the E.M.F. at which electrolysis begins in melted electrolytes. The electrolytes were melted in a glass tube in a bath of molten lead and the current was passed between two carbon electrodes. A series of gradually increasing E.M.Fs. were applied to the electrodes and the corresponding currents measured. The resistances were simultaneously measured by Kohlrausch's method and from these the corrections to be applied to the product of current and E.M.F. were determined. The results were then plotted and the sharp bend in the curve gave the desired point at which the electrolysis started or increased.

In some salts two distinct points of dissociation were well marked corresponding to two different degrees of dissociation analogous to the similar dissociation of water; into the ions HO and O and then H_2 and O. The salts which showed two distinct dissociations were, PbI_2, $CdCl_2$, $CdBr_2$, CdI_2, the E.M.Fs. at which these occurred being in the case of PbI_2 0·396 and 0·705 volt at 495° C., and in $CdCl_2$ 0·715 and 1·225 volt at 563° C. In some of these cases the first dissociation satisfies the condition of reversibility as given by Helmholtz, but not the second, analogous to the two dissociations in water. The haloid salts of Ag, K, and Na have only one point of dissociation and it satisfies the condition of reversibility. J. B. H.

272. *Commercial Electrolytic Generation of Oxygen and Hydrogen.* **W. S. Franklin.** (Amer. Electn. 11. pp. 526–527, November, 1899.)—The electrolytic generator for oxygen and hydrogen made at the Lehigh University is an improved form of that made in the laboratory of the Iowa State College in 1895–6. It is made of cast iron frames insulated with hard rubber, the frames serving as electrodes. The electrolyte is a solution of caustic soda. The gases are kept separate by means of sheet iron baffles set one above the other in a slanting position. The apparatus is fully described with drawings. The tests carried out by H. J. Horn and P. Bucher with this apparatus show that the water may be separated into its two constituent gases, each being of 99·9 per cent. purity, due care being given to the current density and adjustment of the baffle plates. The electrical efficiency proved to be 41 per cent.

The cost in the improved cell is not given, but in the old one it was 1 cent per cubic foot of oxygen, the current costing 2 cents per kw. hour.

J. L. F. V.

273. *Electrolytic Bleaching of Wood Pulp.* **A. Navarre.** (Ind. Électrochim. 3, pp. 49–51, 1899.)—At the works of Bergès and Corbin, the Hermite process, with its many platinum and zinc electrodes and heavy currents at about 6 volts, was given a trial in 1890. In order to avoid dynamos of special design and corrosion of electrodes, Corbin has adopted the following arrangement at Lancey: The trough contains two electrodes at the ends, and eleven intermediate insulated electrodes, all fixed in frames fitting in tightly; the plates are all of platinum and the intermediate plates serve as double electrodes. The connecting cables are fixed outside the trough, and by varying the number of intermediate plates, any tension may be applied. The thirteen plates at Lancey receive currents of 150 amperes at 120 volts.

The electrolyte is sea-salt solution, and the process continuous. Each cell can bleach 750 kg. of bisulphite pulp to extra whiteness. H. B.

274. *Electric Tanning.* **J. Bose.** (Ind. Élect. 8. pp. 344–348, August 10, 1899.)—The author refers to the use of the electric current for promoting the absorption of chemicals by living tissues, and argues from this that electricity must prove of equal service in accelerating the permeation of skins and hides by tanning materials. Grosse in 1849 first employed galvanic action for this purpose; and he was followed by Ward in 1859, Rebu in 1861, de Meritens in 1874, and by Gaulard and Kresser in 1885. Leather tanned by the last-named process was exhibited in London in 1885. In 1889 the methods of Worms and Ballé and of another unnamed inventor, were experimentally tried in London and Paris. The author obtained specimens of leather tanned by the latter process, and found that it wore well when made up into shoes.

The two processes, together with those of Groth and of Burton, are described in some detail, and figures are given relating to voltage, current density, and to the saving of time effected by their use. The Groth process is said to have been in operation in London, in Belgium, and near Lausanne. The Burton process has been tried in America. J. B. C. K.

275. *Electric Tanning.* (Indus. and Iron, 27. p. 83, August 4, 1899.)—Four to twelve months is the time usually taken to tan ordinary sole leather. Groth claims to have reduced this time to one-fifth, and the cost to two-thirds, by his electrolytic method of tanning. The daily absorption of tannic acid by the ordinary process is stated to be 0·183 grm., as compared with 2·08 grms. in Groth's process.

Tests of the finished leather (five weeks' tanning) made by Unwin gave remarkably high results. And equally satisfactory tests were obtained by Parker of the Leatherseller's Company. Details of these are given.

The Groth process is said to be at work in Sweden and Norway, the patents in these two countries having been bought by the Wenersborg Leather Industry Co. J. B. C. K.

276. *Cost of Calcium Carbide.* **F. Liebetanz.** (Zeitschr. Elektrochem. 6. pp. 117–122, August 10, 1899.)—This is a report of an address delivered at the second Buda-Pesth Acetylene Congress in May, 1899. The author seeks to answer the question as to the relative economy of gas-, water-, and steam-power, when used for carbide production on a small scale; it being assumed that the difficulties and costs of distributing carbide will limit the area of effective competition from the factories established at the great centres of water-power.

The estimates are based upon the power and raw materials required for 1,000 kgs. carbide, and the yield of carbide per kw. day of twenty-four hours is taken as 5 kgs.

The gross H.P. necessary to yield 1,000 kgs. carbide per day is therefore 340, or allowing for all losses in the generating machinery, 450.

Taking these figures as the basis of his calculations, the author arrives at the following results for a 450 H.P. plant :—

	Water-fall.	Steam.	River-flow.
Capital outlay	£6,750	£2,800	£3,750
Annual running charges	£675	£1,464	£1,000
Daily running charges	£2 5s. 0d.	£4 18s. 0d.	£3 7s. 0d.
Cost of 1 E.H.P. year at the electrodes of furnace	£2 10s. 0d.	£5 8s. 0d.	£3 14s. 0d.

Adding to these costs of power, the cost of raw materials and labour, the total costs for the production of 1,000 kgs. carbide by the three sources of energy named above, work out to—

Water-falls	£8 18s.
Steam	£11 14s.
River-flow	£9 15s.

The author gives no detailed estimates for the cost of carbide with gas-power, but he is of opinion that the use of blast-furnace gases for this purpose will undergo great development in the near future. J. B. C. K.

277. *Memmo Carbide Furnaces at San Marcel.* **C. Pio.** (Elect. World and Engineer, 34. pp. 195–198, August 5, 1899.)—This works operates with three-phase currents. Some of the facts mentioned in the paper have already received notice (see 1899, Abstract No. 1412). The present article gives useful detailed drawings of the furnace, and its electrical conductor connections, with some notes upon the method of working at San Marcel.

J. B. C. K.

278. *Calcium Carbide Industry at Merano.* (Elettricità, Milan, 18. pp. 406–408, 1899; also Éclairage Électrique, May 6, 1899.)—The hydraulic works of the Gesellschaft Etschwerke, in the Austrian Tyrol, near Merano, are briefly described. They contain five turbines of 1,200 H.P. each direct coupled to three-phase alternators generating current at 10,000 volts. Of this 2,000 H.P. is sold to the Acetylene Gas Co. at 47s. 6d. per H.P. year. For the carbide furnaces the current is transformed down by six three-phase transformers of 260 kw., each giving 2,500 amperes per phase at 33 volts. One phase of each of three of the transformers are connected in parallel for each furnace. The lime is obtained locally in the form of a very pure marble. The furnaces, on the system of Gin and Leleux, are described. They yield 11·4 lbs. of carbide per kilowatt hour, giving 4·8 cubic feet of acetylene per lb. The cost of the carbide is estimated at £7 9s. per ton. L. B.

279. *Polyphase Electric Furnaces.* **R. Memmo.** (Elettricità, Milan, 18. pp. 438–441, 1899.)—In electric furnaces acting merely by heat and not by electrolytic action, alternating offer great advantages over continuous currents. A furnace consisting of several arcs in parallel cannot be run satisfactorily owing to the impossibility of regulation. And the size of single carbon electrodes, and hence the power of a continuous current or monophase furnace is limited. In this direction polyphase currents offer great advantage, the power of the furnace being increased by simply increasing the number of phases up to 20 or 30. They may be arranged in mesh or in star—the latter being preferable, as the arcs have less reaction on each other—the molten mass being employed as the neutral point. This system has also the advantage that one or more of the phases may be employed for lighting or other purpose without interfering with the work of the furnace. L. B.

280. *Experimental Electric Furnace.* **S. A. Tucker.** (Amer. Electn. 11. pp. 408–409, September, 1899.)—A brief account of Moissan's and other electric furnaces for use on a small scale, with a table giving the names, formulæ, discoverers, and certain properties of various carbides formed in such furnaces. W. G. M.

281. *Magnetic Ore Separators.* **E. Langguth.** (Zeitschr. Elektrochem. 6. pp. 321–324, December 7, 1899.)—This paper contains a historical review of the development of the method of separating ores according to their relative magnetic permeabilities. J. B. H.

282. *Manufacture of Liquid Air.* (Eng. News, 41. pp. 368–371, June 8, 1899.)—This paper is a description, with general view and diagrammatic sections of the various parts of the liquid air manufacturing plant of the General Liquid Air and Refrigerating Co., New York City.

It is estimated to produce 1,500 gallons of liquid air per day. It consists of a steam-power refrigerating plant, utilising the expansion of the compressed air to produce a low temperature, and causing this cold air to react upon itself, until the temperature is so low that liquefaction occurs.

Steam is raised at 150 lbs. pressure by three vertical fire-tube boilers, each of 75 nominal H.P. The steam drives four-stage air-compressors connected by intercoolers. Sectional views are given of the cleanser to take the dust out of the air previous to compression, and of the separator for removing oil, moisture, and other impurities from the air after compression, also of the liquefier and after-cooler with details of their valves and coils. The intercooler and after-coolers extract the heat generated by compression, by passing the air over water-cooled tubes. The air, at a pressure of 1,200 lbs. per square inch, and at 50° or 60° F. the temperature of the brine tank, passes to the liquefier coils and through the contracted orifice of the expansion valve adjusted to throttle the flow, and is reduced in pressure from 1,200 lbs. to 300 lbs. per square inch. The drop in temperature so produced is repeated by the cumulative cooling process until the critical temperature of air is reached. Then a portion of the air passing through the expansion valve liquefies and collects in a small reservoir over the after-cooler, and the other part passes into the cooling tubes and is used over and over again. Fresh air is drawn in through the cleanser to take the place of that liquefied. A sectional view and description is also given of a reservoir for storing and carrying the liquid air so that it can be retained in a liquid form. W. R.

REFERENCES.

283. *Primary Batteries.* **W. R. Cooper.** (Electrician, 43. pp. 601–602, August 18, 1899) Historical Notes.—(Pp. 700–702, September 8, 1899) Theory of Grotthus applied to a simple voltaic cell.—(Pp. 800–803, September 29, 1899) Thermal relations in the voltaic cell.—(Pp. 877–880, October 13, 1899, and pp. 916–918, October 20, 1899) Chemical and Contact Theories.

284. *Dissociation Pressure before H. Sainte-Claire Deville.* **P. Duhem.** (Journ. Phys. Chem. 3. pp. 364–378, 1899.)—Historical.

285. *Electrolytic Treatment of Sulphide Ores.* **S. Cowper-Coles.** (Electrician, 44. pp. 81–83, November 10th. Abstract of paper read before the Society of Engineers, November 6th.) Brief descriptions of various systems, including those of Watts, Diffenbach, Ashcroft, Siemens-Halske, Hoepfner's, Mohr's, Swinburne's Processes.—(Pp. 111–113, November 17th) Description of the Author's Process.—(Pp. 157–159, November 24th, 1899) Zinc sponge.

286. *Applications of Electro-metallurgy to Mechanical Engineering.* **S. Cowper-Coles.** (Electrician, 44. pp. 50–51, November 3, 1899.)—Abstract of a paper read before the British Association.

287. *Electrolytic File Sharpening.* **S. Cowper-Coles.** (Elect. Rev. 45. pp. 704–705, November 3, 1899.)

STEAM PLANT, GAS AND OIL ENGINES.

288. *Steam Engines for Electric Traction.* **C. A. Hague.** (Eng. Mag. 18. pp. 425–430, December, 1899.)—Probably the steam engine has never been called upon to do work of so variable a character as that of developing power for a street railway, and in selecting a type of engine for street railway work the extreme variation of load is a factor of great importance. With a plain slide-valve engine controlled by a throttling governor the widest range of work affects the steam economy but slightly; with the compounds, triples and quadruples the expected economy, due to limited range of cylinder temperatures, cannot be closely realised except by keeping nearly to ideal conditions for the particular type in hand. In a railway power plant, owing to the variations of load, the choice of the steam engine lies somewhere between a naturally wasteful engine whose economy cannot be easily injured and a very economical type whose best economy cannot be maintained. This choice seems to point to the cross-compound condensing engine for units of 1,000 H.P. and upwards. The average steam consumption in a traction power house of simple non-condensing, cross-compound condensing, and triple condensing engines may be represented by the figures 130, 125, and 150 respectively, the steam consumption for each type of engine under a steady load being taken at 100. The question of storage batteries and triple expansion engines is sometimes raised, but the interest and maintenance accounts prevent their adoption for large plants for railway power. Cheap money and dear fuel may possibly lead to a readjustment of conditions.

The question of speed and voltage regulation is discussed, and it is pointed out that, while the electrical engineer requires a constant voltage with varying power, the cotton spinner requires uniform speed with varying power.

The author discusses the regulation of the steam engine by throttling the steam for very short cut-off, and in combination therewith varying the point of cut-off further out in the stroke with full initial pressure. The general statement of the problem of the steam engine for electric traction is sufficient to indicate its peculiar difficulties. A. S.

289. *Experiments upon Engine Governors.* **W. G. Hibbins.** (Instit. Civ. Engin., Proc. 137. pp. 376–401, August, 1899.)—The characteristic speed curve from a governor, in which the revolutions of the governor are plotted as abscissæ and the lift of the governor sleeve as ordinates, consists of two curves due to the sleeve rising and falling respectively. The difference between the two curves is due to the frictional resistances of all the pieces connected to the sleeve. The author made experiments at Mason College, Birmingham, under the superintendence of R. H. Smith, on Tangye (Soho), Acme, Lüde, Proell, Watt, Porter, Pickering, Turner-Hartnell, and Belliss governors, and obtained speed curves; in the case of the spring loaded governors, different loads were placed on the spring. In a series of speed curves for one governor the mid-position of the sleeve is indicated by a horizontal line drawn across the curves. At the points where this base-line is intersected by any pair of curves the corresponding load or spring-pull is plotted off as a pair of vertical ordinates. By joining the series of points so obtained, two almost parallel straight lines are obtained for all the governors experimented on, the upper one corresponding to the "down" curve, and the lower one to the "up" curve. From the diagrams the "sensitiveness," "controlling force," and "controlling energy" are easily obtained. The chief results obtained from the nine governors tested are exhibited in a table. As regards the controlling force, the small Tangye governor has a high value; it is, however, lacking in sensitiveness. The Turner-Hartnell governor has a large controlling force, and a large amount of frictional resistance in its working parts. The highest values of the controlling force are exhibited by the governors which have either heavy balls, weights, or heavy central loads. The Proell governor appears to be far superior in sensitiveness to the rest. The Porter governor compares favourably with some of the more modern types, possessing both sensitiveness and great controlling force.

In a summary of the results arrived at, the author makes the following statements: The controlling force of a governor is increased by increasing the weight of the balls or the central load. The controlling force and sensitiveness are increased by providing the governor with powerful springs. Shaft governors can be made more powerful, bulk for bulk, than vertical governors. The advantages of the more modern types, such as well-designed Watt and Porter governors, are not so great as perhaps might be expected.

A. S.

290. *Fuel Economy of Steam Engines for Traction.* **R. C. Carpenter.** (Street Rly. Journ. 15. pp. 801–804, November, 1899. Paper read before the New York State Street Railway Association.)—The results are given of thirty-five tests of electric railroad power stations made under the ordinary conditions of operation in which the economy is affected to a great extent by variation in load, and by poor or good firing; the latter often makes 20 per cent. or more difference in fuel economy. The steam consumption at normal steady load of 120 I.H.P. by a simple non-condensing automatic slide-valve engine was slightly over 27 lbs. of steam per I.H.P., nearly 30 lbs. at 150 H.P., 44 lbs. at 60 H.P., and 64·3 lbs. at 40 H.P. The average results show a consumption only about 25 per cent. higher than obtained with this class of engine under most favourable conditions, or about 34·3 lbs. of steam and 4·63 lbs. of coal per I.H.P. hour. With non-condensing simple Corliss engines under favourable conditions 23 lbs. to 25 lbs. of steam might be used per I.H.P., while the average of the tests under working conditions, being slightly over one-half of the rated capacity, was 28·3 lbs. per I.H.P. hour.

Reducing test results to uniform evaporation, the compound non-condensing engine was 9·4 per cent. more economical in use of coal, and about 5·5 per cent. more economical in use of steam than the simple non-condensing engine. The compound non-condensing engine under best load conditions would use 22 lbs. to 23 lbs. of steam, or nearly 33 per cent. less than under power-house conditions, but the data for this deduction are limited.

The compound condensing slide valve or high-speed automatic engine uses 15 lbs. of steam under favourable load conditions, but under working conditions the consumption would be 30 per cent. or 40 per cent. more. Compound condensing Corliss, Greene, McIntosh and Seymour and engines having similar valve motions consume 15 lbs. or less with favourable load, which is increased by about 20 per cent. under working conditions. The average boiler evaporation from and at 212° was 10·26 lbs. for stations using simple non-condensing engines, 9·82 lbs. for stations using compound condensing slide valve engine, and 10·54 for stations using compound condensing Corliss engines per lb. of fuel. The estimates of the cost of plant are exclusive of real estate, buildings, and chimneys, and the estimates of working expenses do not include wages and oil. The author concludes from the tests that compound condensing slow speed engines with improved valve gear are much the better investment.

SUMMARY OF TESTS.

No.	H.P. of Engine.	Steam per I.H.P. Hour.	Actual Coal per I.H.P. Hour.	Mean Observed I.H.P.	Per Cent. Observed HP. to Capacity.	Boiler Evaporation per lb. Combustible from and at 212°.	Kind of Coal.
SIMPLE NON-CONDENSING SLIDE-VALVE ENGINES.							
6	200	34·8	4·47	110	55	11·50	Pea A
1	405	34·5	(*a*) 6·54	257	63·4	(*a*) 9·11	Culm, East Ohio
7	1,975	35·7	4·60	862	51	9·46	Bit. W. Pa.
11	300	37·3	4·49	90	44	12·20	Bit.
11	300	34·3	4·72	95	46·7	10·20	Bit. Ill.
24	1,000	31·8	(*b*) 5·38	717	71·7	(*b*) 9·15	Bit.
31(*c*)	270	41·5	(*c*) 5·50	126	47·5	(*c*) 10·60	Ant. Buck.
33	270	31·6	4·61	147	54·5	10·70	Ant. Pea
Average		35·1	5·07	...	54·2	10·24	
Average neglecting (*c*)......................		34·3	...	...	...	...	
Average neglecting (*a b c*)		...	4·63	...	...	...	

Remarks.—Engine in test (31) in bad condition. Probable average coal per I.H.P. hour, when using anthracite or eastern bituminous, 4·63 lbs.; anthracite culm, 6·54; western bituminous, 5·38. Coal per kw. output averages 50 per cent. higher, or 6·94, 9·81, and 8·07 respectively. Probable error for any given case not over 10 per cent. Steam pressure, 90 lbs. to 120 lbs.

No.	H.P. of Engine.	Steam per I.H.P. Hour.	Actual Coal per I.H.P. Hour.	Mean Observed I.H.P.	Per Cent. Observed HP. to Capacity.	Boiler Evaporation per lb. Combustible from and at 212°.	Kind of Coal.
SIMPLE NON-CONDENSING CORLISS ENGINE.							
17	300	30·1	3·09	139	46	11·45	Clearfield Bit.
19	150	26·9	3·5	90	60	9·73	Ant. Buck.
22	350	28	3·77	153	44·7	8·55	Ohio Bit.
Average		28·3	3·45	...	50·3	...	
COMPOUND NON-CONDENSING ENGINE.							
2	1,000	30·5	4·22	603·5	60·3	9·03	Bit., 3 parts Ant.
4	1,250	36·8	4·33	674	53·8	9·92	Culm, 1 part. Bit. slack
21	400	34·20	4·17	203	51	10·23	Bit. Penn.
24	1,200	30·37	4·93	754	62·7	9·01	Bit. Ill.
Average 21 and 24		32·28	4·55	...	...	...	

Remarks.—Test No. 2 was made on three simple engines 150 H.P., one cross compound 250 H.P. and one triple 300 H.P. Test No. 4 was made on three simple engines 250 H.P. each, and one compound of 500 H.P. Steam pressure, 100 to 125 lbs.

SUMMARY OF TESTS—*continued.*

No.	H.P. of Engine.	Steam per I.H.P. Hour.	Actual Coal per I.H.P. Hour.	Mean Observed I.H.P.	Per Cent. Observed H.P. to Capacity.	Boiler Evaporation per lb. Combustible from and at 212°.	Kind of Coal.
COMPOUND CONDENSING SLIDE-VALVE OR HIGH-SPEED AUTOMATIC ENGINE.							
3*a*	600	29·4	4·43	174	29	10·38	3 parts A ; 1 pt. Bit.
3	600	23·2	3·50	190	32	9·93	1 part Bit.
8	400	20·2	3·14	154	38	8·29	Ohio Bit.
8*b*	400	16·7	2·40	180	45	7·75	Ohio Bit.
13	250	24·6	2·95	86	34·5	10·51	Bit. Penn.
16	350	22·7	3·41	164	47	9·50	Ant. Pea
18	1,200	25·6	3·61	904	75	10·58	Pea Penn.
21	400	29·3	3·81	188	47	10·23	Bit.
Average		23·96	3·41	...	...	9·64	
Average except 3*a* and 8*b*		24·26	3·40	...	...	9·82	
Average omitting 3*a*, 18, 21, and 8*b*		22·7	3·25	...	...	...	
Steam pressure, 100 lbs. to 130 lbs.							
COMPOUND CONDENSING, CORLISS, GREENE, MCINTOSH AND SEYMOUR, AND SIMILAR VALVE MOTIONS.							
10	825	22·7	4·06	482	58·2	8·29	½ Bit. Slack. ½ A Culm.
14	1,000	21·9	2·56	277	27·7	10·96	Bit.
14	1,000	20·0	...	314	31·4	10·96	
28	350	16·64	2·10	182	52·2	11·80	Bit.
27	500	16·90	2·61	290	58	9·36	Bit.
30	2,000	14·50	1·80	814	40·7	10·70	Bit.
34	200	17·30	2·91	145	72	11·14	Bit.
35	1,600	20·50	2·18	...	...	11·14	Bit.
Average		18·8	2·60	...	...	10·54	
Evaporation, 7·25 to 1 of coal.							
Average omitting No. 10		18·25	2·36	...	...	...	
Evaporation, 7·78 to 1 of coal.							

SUMMARY OF AVERAGE RESULTS.

CLASS OF ENGINES.	Steam per I.H.P. Lbs.	Coal per I.H.P. Lbs.	Steam per I.H.P. Lbs. Best Load.	Proportional Value of Engine.	Probable Coal per kw., lbs.
(A) *Non-condensing.*					
Slide valve simple, average	34·3	4·63	30	53·1	6·90
Best result	31·6	4·61	...	...	...
Corliss simple, average............	28·3	3·45	25	64·5	5·65
Best result	26·9	3·01	...	...	...
Slide valve, compound, average	30·37	4·17	22	60·2	6·12
(B) *Condensing.*					
Slide valve, compound average	22·7	3·25	16	80·5	4·57
Best result	16·7	2·40	...	...	3·60
Corliss, compound average	18·2	2·36	15	100	3·64
Best result	14·5	1·80	...	...	2·70

COST PER H.P. OF 500 H.P. PLANT.

	Boiler H.P. per Engine H.P.	Cost per H.P. in Dollars.					Cost for 500 H.P. Plant.
		Engine.	Boiler.	Pumps and Heaters.	Piping, &c.	Total per I.H.P.	
Non-condensing Engines.							
Simple slide valve	1·135	8·00	13·60	2·00	5·00	28·60	14,300·00
Simple Corliss	0·933	12·00	11·20	2·00	5·00	30·20	15,100·00
Compound slide valve ...	1·00	11·00	12·00	2·00	5·00	30·00	15,000·00
Condensing Engines.							
Compound slide valve ...	0·75	11·00	9·00	4·00	6·00	30·00	15,000·00
Compound Corliss	0·602	16·00	7·25	4·00	6·00	33·25	16,625·00

FUEL AND INTEREST CHARGES FOR THE DIFFERENT CLASSES OF ENGINES.

	Coal per I.H.P. Hour.	Tons per H.P. per Year.			Fuel Cost per Year. 18 Hours per Day. $2 per Ton.	Interest and Depreciation, 8 per cent.	Total Cost per Year per H.P.
		Day, 12 Hours.	Day, 18 Hours.	Day, 24 Hours.			
Non-condensing Engines.					$	$	$
Simple slide valve, average	4·63	10·4	15·21	20·28	30·42	2·29	32·71
„ „ „ best	4·60	10·7	15·10	20·14	30·20	2·29	32·49
Simple Corliss, average............	3·45	7·55	11·33	15·10	22·66	2·42	25·08
„ „ best	3·01	6·59	9·89	13·18	19·78	2·42	22·20
Compound slide valve	4·17	9·05	13·57	18·10	27·14	2·40	29·54
Condensing Engines.							
Compound slide valve, average	3·25	7·12	10·68	14·24	21·36	2·40	23·76
„ „ „ best ...	2·40	5·25	7·88	10·51	15·76	2·40	18·16
Compound Corliss, average	2·36	5·17	7·74	10·33	15·48	2·64	18·12
„ „ best...........	1·80	3·94	5·91	7·88	11·82	2·64	14·46

J. T. R.

291. *Water-tube Boilers for Marine Engines.* **J. T. Milton.** (Instit. Civ. Engin., Proc. 137. pp. 167–201. Discussion, pp. 242–305, August, 1899.)—There is considerable difference between the conditions of work to which boilers are subjected in warships and those experienced in merchant vessels. This accounts for the more ready introduction of water-tube boilers into the former class of vessels. Greater economy and durability are demanded in a water-tube boiler for the merchant navy. After inherent strength of form, the essential elements to be provided for are complete combustion, even at high rates and with minimum air-supply, and ready transmission of heat. The mean velocity of the hot gases over the heating surface having been shown to be about 26 feet per second, it follows that no portion of these gases remains in a boiler for more than one second. The arrangement and size of flues may, however, modify this result. The circulation of the water in boilers, as demonstrated on the basis of experiments by Yarrow, Thornycroft, and Blechynden, does not lead to any definite conclusion as to the advantage of, or necessity for, a high speed of circulation. The following water-tube boilers are compared with the "Scotch" boiler and described in the paper, viz. :—the Belleville with economiser, Lagrafel-D'Allest, Niclausse, Babcock-Wilcox marine type, Yarrow, Fleming-Ferguson, Reed, Normand, Thornycroft, Blechynden, Mumford and Haythorn—examples of all of them being quoted. The paper concludes with remarks on the importance of treatment, and on the effects of thickness of material, and of curvature of tubes on durability. In the discussion **J. List** stated that in mail-steamer work the limit of steam pressure with tank boilers had practically been reached. They were using double-ended eight-furnace boilers, 17 feet mean diameter and 19 feet 2 inches long, for a working pressure of 210 lbs. per square inch. The boiler shell-plates were $1\frac{21}{32}$ inch thick, and the furnaces were 44 inches internal diameter and $\frac{11}{16}$ inch thick—the steel of the shells having an ultimate tensile strength of between 31 and 34 tons per square inch. Weight of such a boiler with mountings was 115 tons, and the water was 49¼ tons additional. Comparing Belleville boilers for similar work at 300 lbs. per square inch pressure, it was found that they had 4½ per cent. less total heating surface than the tank boilers; weighed 40 per cent. less; saved in length of space 13 per cent.; but cost 50 per cent. more in first cost. F. J. R.

292. *Niclausse Water-tube Boiler.* **M. Robinson.** (Elect. Engin. 24, pp. 456–462. Discussion, p. 462, October 13, 1899.)—Compared with the Babcock-Wilcox land type and the Yarrow, Thornycroft, and Belleville marine boilers, the Niclausse boiler possesses features which make it a distinct type. Composed of tubes of 3 to 4 inches diameter, slightly inclined from the horizontal, it has headers only at one end of them, the other end being left free, so that there is no rigidity to resist expansion lengthwise. The free end of the tube is closed with a screwed cap, and the front end is secured by two coned joints to both outer and inner walls or faces of the header, but communicates only with the inner of two chambers or passages into which the header is divided by a partition. The outer passage is in communication with a number of smaller tubes, one of which is inserted concentrically into each of the larger generating tubes, for circulation of water. At the top of the header is the steam drum, and as the water level in it is some distance above the header, circulation commences as soon as heat is applied to the tubes. This does not take place in such boilers as Thornycroft's where the tubes deliver steam above the water-line. The water flows down the outer or downcast half of the Niclausse header, through the small inner tubes, which project nearly the full length of the generating tubes, and back by the outer tubes, the steam and foam escaping by the upcast half of the header. The tubes are connected "in parallel," as in the Babcock-Wilcox boiler, and not "in series," as in the Belleville, so that the circulation is freer than in the latter. The constructive details have been arranged with a view to ease of examination and repair. Originally constructed in France, this boiler has done well in vessels of the navy there and on shore. Since its introduction into the Royal Navy and some electric light installations in England improvements have been made in details. In the trials of the boilers of the *Temeraire*, on land, an evaporation of 11·25, 10·12, 10·72, and 10·3 lbs. of water from and at 212° Fahr. per lb. of coal was obtained with draught of 1·1, 1·5, 2·7, and 4·3 inches of water respectively, the lbs. of steam evaporated per square foot of heating surface having been 4·6, 10·6, 13·2, 15·9 for the different rates of combustion.

Experiments made in Paris on the comparative value for evaporation of the successive stages of tubes in a model boiler showed that nearly ¼ of the whole evaporation was due to the first row, and nearly ½ to the first three rows which had 7·5 square feet of heating surface for each square foot of grate.

The first six rows, with a surface ratio of 15 to 1, evaporated nearly ⅔ of the whole, and the last, or twelfth, row evaporated only about 8¾ per cent. The value of additional surface can thus be estimated. F. J. R.

293. *Recent Trials of the Machinery of Warships.* **A. J. Durston** and **H. J. Oram.** (Instit. Civ. Engin., Proc. 137. pp. 202–241. Discussion, pp. 242–305, August, 1899.)—In November, 1894, the Engineer-in-Chief of the Royal Navy gave in a paper (Min. Proc. Inst. C.E. 119. pp. 17–46) details of the machinery of the seventy vessels built under the Naval Defence Act of 1889, and the present paper gives similar details of the vessels added to the Navy since that date. In the case of the ten battleships now fitted with water-tank boilers the proportion of heating surface per I.H.P. is increased over former practice on the recommendation of the Admiralty Committee on designs of machinery. The results as to weight are as follows :—

EIGHT VESSELS BUILT UNDER NAVAL DEFENCE ACT.

Mean I.H.P. developed.	Average Steam Pressure. Boilers.	Heating Surface per I.H.P. (mean).	Weight in lbs. per I.H.P. (mean).	
			Engines.	Boilers.
	lbs. per sq. in.	sq. feet.		
11,500	149	1·7	113	116
9,430	150	2·1	146	141

AVERAGE OF TEN BATTLESHIPS BUILT SINCE NAVAL DEFENCE ACT.

Mean I.H.P. developed.	Average Steam Pressure. Boilers.	Heating Surface per I.H.P. (mean).	Engines.	Boilers.
12,414	149	2·0	111	131
10,404	148	2·4	132	156
6,170	140	4·1	261	486

Maximum power is obtained in all these vessels by forced draught on the closed stoke-hold system, except in two, fitted with induced draught apparatus. The I.H.P. developed per ton of machinery is less in the latter than in the former vessels, but the machinery is rather more substantial. The 1st class cruisers having triple-expansion engines with four cylinders and four cranks, but fitted with Belleville boilers, without economisers, show :—

I.H.P. developed.	Steam Pressure. Boilers.	Heating Surface per I.H.P.	Weights per I.H.P.	
			Engines.	Boilers.
5,058	216·5	...	...	...
18,479	227·5	3·66	130	140
22,547	231·0	3·00	107	115
25,774	243·0	2·63	94	100

There is a gain in I.H.P. per ton of machinery. In other examples of warships of the 1st class the steam pressure employed is 300 lbs. per square inch in the boilers with economisers, engines with four cylinders (triple-expansion) are used, and the I.H.P. per ton of machinery amounts to 12·14 in some instances. Similar results are given in tables for 2nd and 3rd class cruisers, and for torpedo-boat destroyers; and a further table (vi.) gives details of weights and space occupied for the machinery of four groups of vessels, The authors discuss the best number and arrangement of cylinders in the engines; the distribution of power between them; the arrangement of cranks, and the effect of different distributions of the turning moments in production of vibration in the ship, with results obtained. The fitness of various designs of water-tube boilers for special work is pointed out, but on the question of durability, the only definite result as yet reached, is that the life of the boiler tubes of the Belleville boilers will not be less than two commissions. No difficulty has been experienced in working with a boiler pressure of 300 lbs., and an engine pressure of 250 lbs., and the influence of increased pressure on economy of weight and space has been considerable.

F. J. R.

294. *F. H. Smith's System for Gas and Oil Engines.* (Feilden, 1. pp. 366–368, October, 1899.)—The horizontal gas engine invented by F. H. Smith is of the two-cycle type, giving an explosion every revolution, and is designed to occupy small space and have simple mechanism. The exhaust gases are expelled and the new charge drawn in by an *auxiliary piston* during the end of the explosion and the early part of the compression stroke. The engine has no pretensions to ultimate design, and is illustrated by an external view and longitudinal section of a working model, the cylinder only 2¼ inches diameter and the stroke 3 inches. An indicator diagram, taken at full load, shows compression 28 lbs. and maximum explosion pressure 132 lbs. per square inch above the atmosphere. The main piston, joined to the crank shaft by a connecting rod, is hollowed out to receive a guide tube fixed to the inner piston next the combustion chamber. Inside the tube there is a strong spiral spring which connects the two pistons and works the inner one. The gas and air inlet port near the crank end of the cylinder is closed and opened by the main piston. During the explosion-stroke the two pistons are forced out together, compressing the spiral spring between them. When the exhaust valve is opened by a lever and cam on the crank shaft, the inner piston is sprung back rapidly, by the compressed spring, to the combustion end of the cylinder, driving out the exhaust gases, and at the same time drawing in the new charge between the two pistons. On the return stroke of the main piston the inlet port is closed and the charge is compressed through the non-return valve in the inner piston into the combustion-chamber. Electric ignition of the charge takes place just before the dead centre, and the explosion drives the pistons out together again.

The inner piston, actuated by the spiral spring, controls the speed of the engine. The amount of the charge drawn in is regulated by the time taken by the inner piston in traversing the cylinder. When the load is suddenly thrown off the engine, though the speed may be momentarily accelerated, the inner piston has not time to complete the full journey to the farther end of the cylinder, and therefore a smaller charge is taken and added to a larger residue of burnt gases as a diluent for a weaker explosion. Consequently the speed gradually slows down automatically.

Only the combustion-chamber end of the cylinder is cooled by a water-jacket. The weak point in the design appears to be the spring which actuates the inner piston. The inventor states that after running for several months the spring in the model had not altered in any way, the cold charge passing round every revolution keeping it cool. W. R.

295. *Evaporative Condensers.* **H. G. V. Oldham.** (Instit. Mech. Engin., Proc. 2. pp. 185–207. Discussion, pp. 207–254, April, 1899.)—These are suitable where there is insufficient water for jet or surface condensation, the condensing water being about one-fortieth that required for surface-condensing. Tubular principle, steam and water distribution, and various forms of condensers are described, and the steam-condensing value of air circulation by a fan is given. One square foot of tube surface will condense a maximum of 8 lbs. of steam and evaporate about 5 lbs. of water per hour. In horizontal wrought-iron tube condensers each square foot should condense from 2 to 4 lbs. of steam per hour.

In the discussion **B. Donkin** thought sufficient attention had not been paid to the question of dirt on the tubes and in the circulating water. **M. Longridge** considered there was a great diversity of opinion as to the amount of surface required. He should say that 35 or 40 square feet were required per lb. of steam condensed per minute. **L. Andrews** said that a Wright condenser had been in use at Hastings electric light station for about twelve months without satisfactory results, and described experiments to improve the results. **H. B. Spencer** described the Klein water cooler, and **C. J. Barley** an oil separator and Ledward condenser, and its results. **W. H. Patchell** thought the general conclusion was that the cooling water required was equal in weight to the steam condensed. **W. Brown** described a condenser for 550 I.H.P. to condense about 1½ lbs. of steam per hour per square foot of surface, occupying 2 square feet of floor space, and weighing 16 cwt. for each 20 lbs. of steam condensed per hour. **H. Boot** wrote of rapid deterioration due to dirt on the tubes. **H. G. V. Oldham** communicated further information and the following table :—

WEIGHT OF STEAM CONDENSED PER HOUR PER SQUARE FOOT OF CONDENSING SURFACE.

Condensers with Horizontal Tubes without Fans.	Lbs. per Hour.	Quantity of Cooling Water per Hour.
Cast iron plain tubes	1 to 1½	10 to 15 times weight of steam condensed.
Cast iron plain tubes exposed to good, steady wind	1½ to 2	
Cast iron corrugated tubes, Ledward pattern	1¼ to 1½	
Wrought iron galvanised tubes, Fraser design	2 to 2½	5 to 10 times weight of steam condensed.
Wrought iron galvanised or copper tubes in good position on roof	2½ to 3	
Condensers with Vertical Tubes.		
Cast iron plain tubes	1½ to 2	10 to 15 times weight of steam condensed.
Brass tubes without fan, and exposed	3 to 3½	
„ „ with fan at slow speed	4 to 5	
„ „ with fan at higher speed and good water circulation	5 to 6	

On wet and windy days the weight of steam is increased 15 to 20 per cent.

There are numerous illustrations and diagrams with this paper. J. T. R.

296. *Lepape's Carburetter.* (Automotor Journal, 4. p. 64, November, 1899.) —This article describes one of the new forms of spray-making, air-rush carburetter now being developed in preference to the surface evaporator commonly used, more especially for motor cycles. An essential feature is the arrangement by which a cap, forming the exterior of a small air vessel, actuates a pair of small valves in an oil-measuring chamber at each suction-stroke of the motor piston. During the period of no-suction-stroke, oil flows into the measuring chamber past one valve, which is closed by the descent, with the cap mentioned, of the second small valve. The suction by the motor piston withdraws the measured oil, which is disintegrated in its passage from the chamber and its vaporisation completed in its further mixture with air, which is admitted by an adjustable inlet, previous to its mixture with the main body of air on its way to the motor cylinder. W. W. B.

297. *Blast-Furnace Gases for Motive Power.* **H. Allen.** (Feilden, 1. pp. 48-60, August, 1899.)—The author is associated with B. H. Thwaite, the inventor of the Thwaite-Gardner system for the conversion of heat into motion, by the utilisation of the waste gases from blast furnaces in the cylinder of the internal combustion engine.

Whilst 600 to 700 cubic feet of blast-furnace gases burned under steam boilers can develop in the steam engine cylinder 1 I.H.P. hour, the same volume of this gas in a suitable gas engine gives 5 to 7 I.H.P. hours. In this way one I.H.P. hour is developed for every 1·3 to 2 lbs. of fuel charged into the furnace for smelting the iron. In present practice the air blast is heated to 1,200° or 1,400° Fahr. and supplied to the blast furnace at 5 to 10 lbs. per square inch above atmospheric pressure. When coke is used 170,000 to 180,000 cubic feet of gases are given off for each ton of coke consumed, and with raw coal 130,000 cubic feet of gas, measured at 60° F. per ton of fuel. The proportion of combustible gas, carbonic oxide and hydrogen, is higher for coal, and is not dependent always on the weight of fuel required to produce a ton of pig iron. Some furnaces using 28 cwt. of coke per ton of pig iron give off gases poorer in combustible than others taking only 19 cwt. of coke. The poorest gases are from coke-fed furnaces, and the percentage by volume is of carbonic oxide 25 to 35, and of hydrogen about 2 per cent., with marsh gas about 0·5 to 2 per cent. Blast-furnace gas, of heating value 120 British thermal units per cubic foot, when used to drive gas engines, gives one I.H.P. for about 100 cubic feet of gas per hour. This waste gas has been utilised (1) to heat the blast by combustion in hot blast stoves, (2) to generate by steam in gas-fired boilers the power required for the blast, pumping, and hoisting machinery. In the gas engine the gas gives four or five times this power, available for electric distribution.

For instance, it is calculated that in a blast furnace producing 600 tons of pig iron per week, with a consumption of one ton of coke per ton of pig iron, 3·57 tons of coke are used per hour and the gases evolved are 607,070 cubic feet per hour. Allowing one-third of this for heating the blast, and 10 per cent. waste into the atmosphere, this leaves 334,007 cubic feet of gas available for power purposes. At a heating value of 95 British thermal units the gas engine requires 140 cubic feet of this gas per I.H.P. hour, and we have a gas supply equal to 2,386 I.H.P. The blast takes 275 I.H.P., and hoisting absorbs 30 I.H.P., leaving for electric distribution or other purposes 2,081 I.H.P. The waste of gas into the atmosphere might be reduced, and for every 1·8 lb. of coke charged into the blast furnace for smelting the pig iron, under ordinary working conditions, one I.H.P. hour may be developed from the gases evolved.

When boilers are retained for stand-by purposes, the circulating water for keeping the gas engine cylinder cool is available as feed water, and some of the waste heat is utilised. The blast furnace need not be blown out, but kept in operation continuously for producing power, which may be employed: (1) by gas engines driving air-blowers; (2) the cleansed and filtered gas can be distributed without any loss due to condensation, as in the case of steam, and used in the gas engine to drive machinery and to generate electric current for light and power.

In the Westphalian iron district in Germany a Thwaite-Gardner plant has been put down to use blast-furnace gas, generating electric current for the manufacture of calcium carbide. The gas from the blast-furnace, after purification, condensation, and filtration, is used to drive a gas engine of 150 I.H.P. The supply of gas is maintained constant by a combined exhauster and blower. The average composition of the gas by volume is:—

Carbonic acid	CO_2	7·8
Carbonic oxide	CO	30·7
Hydrogen	H_2	3·3
Marsh gas	CH_4	0·5
Nitrogen	N_2	57·7
		100·0

The heating value of the gas, down to 212° F., is 111·7 British thermal units per cubic foot at 60° F. The mean pressure in the gas engine cylinder, from the indicator diagram, is 60 to 70 lbs. per square inch. The engine has two cylinders, and at full load there is an explosion every revolution. For small blast furnaces in manufacturing areas the power developed can be disposed of to the best advantage. (See also 1898, Abstracts Nos. 991, 992 and 993.) W. R.

298. *Modern Steam Waggons.* **G. A. Burls.** (Automotor Journal, 4. pp. 53–56. Discussion, pp. 56–58, November, 1899. Read before the Civil and Mechanical Engineers' Society.)—This paper summarises the part of the Locomotives on Highways Act, 1896, which deals with the tare limits for the heavier vehicles. The author proposes that the three-ton limit should be raised to four tons, that the gross load per inch width of tyre should be as much as two-thirds of a ton, or 1,490 lbs., and that a speed of six miles per hour should be allowed. Incidentally it is remarked that heavy load horse waggons which have proved durable at from three to four miles per hour soon give way with the same loads at seven to eight miles per hour. Figures are given, and the power required is calculated, for "steamobiles" to carry on the four-ton tare limit a useful load of eight tons, and with assumed road resistances of which tables are given.

The influence of tyre width is dealt with and reference made to the Royal Agricultural Society's trials at Birmingham in 1898 (Rep. Jour. Roy. Ag. Soc. vol. ix. part 3, pp. 460–491), experimental figures from which are given.

An analysis is given of all the costs of running a Thornycroft steam waggon for a whole year, doing an average of 34 waggon miles per day, carrying a load making 110 net ton-miles per day, which in the year amounted to 8,500 miles of running and 27,500 net ton-miles, at a total running cost of 3·1d. per net ton-mile. This is compared with the cost of horse haulage on a large scale, which amounts to 6d. per net ton-mile. A table accompanies the paper giving dimensions, results of trials, and cost of running of a large number of British and foreign steam vehicles.

In referring to liquid fuel as used in some motor vehicles an expression is given for the quantity of petroleum discharged and burned per hour from orifices, such as those of the Brickford burner, working under different air pressures; it is as follows :—

$$Q = 1050\omega\sqrt{p},$$

Q being oil discharged per hour in pints, ω area of orifice in square inches, and p air pressure in lbs. per square inch. W. W. B.

299. *Renault Motor-Voiturette.* (Indus. and Iron, 27. p. 301, November 3, 1899.)—This article describes a special form of transmission gear which differs from that ordinarily employed in this class of vehicle. It is completely enclosed in an oil-tight gear-case, and the interchanging of the speed gears is effected by the eccentric movement of the shafts carrying the intermediate spur pinions, as in some lathe heads. The reversing gear is also enclosed in this case, and the whole is controlled by one hand-lever and a pedal. The power is transmitted from the speed-gear mechanism, by means of a Hook's joint, to a bevil-pinion, gearing with a bevil-wheel on the exterior of the differential-gear on the rear or driving axle. The carriage is fitted with a 2¼ H.P. de Dion motor, carries two persons, and has run from Paris to Rambouillet, 64·6 miles, in 2 hrs. 49 min. (Eng. Pat. 3981, 1899.) W. W. B.

300. *Acetylene for Autocars.* (Archiv. Post Tele. 11. pp. 555–568, 12. pp. 602–612, June, 1899.)—The author predicts that when safe methods of generating and storing acetylene have been discovered it will displace petrol as the explosive agent in motor-car engines. Acetylene explodes best when mixed with 12 parts of air, whereas the best proportion for coal gas is 6 parts of air. The fuel for 10 H.P. for 100 hours, which in a Serpollet Generator occupies 4 cubic metres, and in a Petrol motor 316 cubic decimetres, only requires 300 cubic decimetres in an acetylene engine. Moreover, acetylene is more cleanly and smells less. Ravel has experimentally found that the efficiency of acetylene is two and a half times as great as that of ordinary coal gas, but he concludes that a type of gas engine suitable for it has yet to be found. Claude and Hesse have shown that, under a pressure of 12 kg. per sq. cm., 1 litre of acetone will absorb no less than 300 litres of acetylene, all of which it will give off again upon lowering the pressure. E. H. C.-H.

301. *W. H. Newman's Variable Speed Gear.* (Engineer, 88. p. 552, December 1, 1899.)—One end of the shaft runs at constant speed, the other is driven at variable speeds within the limits of the mechanism. A spur pinion is fixed to the end of the varying speed shaft, and is set centrally within the case enclosing the gear. Three wheels mesh with this pinion, and each is driven by a roller "free-wheel" clutch. A crank pin is fixed to the disc of each clutch by a limb from an eccentric plate. The eccentric is driven by the constant speed shaft, and the three clutches reciprocate more or less as its throw increases or decreases. The throw of the eccentric is regulated by a hand wheel and screw. No appreciable knock occurs when the gear is running at its highest speed. A. S.

REFERENCE.

302. *Separate Condensing Plants for Factory Purposes.* **A. S. Haslam.** (Instit. Civ. Engin., Proc. 138. pp. 418–420, October, 1899; also Engineer, 87. p. 615.)—Comparison between injection, ejector, submerged or closed surface, and evaporative or open-air condensers. J. T. R.

GENERAL ELECTRICAL ENGINEERING.

303. *Jeanty Primary Battery.* (Elettricità, Milan, 18. pp. 404–406, July 1, 1899.)—This is a battery of the Daniell type with special arrangements for maintaining a constant supply of sulphate of copper. On a trial of thirty-four days' continuous use it consumed 14½ lbs. of commercial sulphate of copper and 3 lbs. of impure zinc per kilowatt hour, costing 15 pence. It is being employed experimentally to operate a system of electric railway signals by the Chemin de Fer del'Ouest, and for lighting the Paris excursion steamer *le Touriste.* L. B.

304. *Mershon Compensator.* (Amer. Electn. 11. p. 434, September, 1899.)—The object of this device is to obtain correct readings of the feeding-point P.D. in an alternating current network without the use of pilot wires. The arrangement of connections as used by the Westinghouse Co. is as follows. The station voltmeter is joined in series with the secondaries of three transformers. The primary of the first transformer is across the generator terminals. The primary of the second transformer, which has an open magnetic circuit, is joined in series with the feeder. The primary of the third transformer (closed magnetic circuit) is connected as a shunt across a non-inductive resistance also in the main circuit of the feeder. The non-inductive resistance bears the same ratio to the total resistance of the feeder as does the inductance of the primary of the second transformer to the total inductance of the feeder. If everything is properly adjusted, the station voltmeter may under these conditions, be made to read the feeding-point P.D., the open magnetic circuit transformer subtracting from the voltmeter circuit an amount proportional to the inductive drop, and the transformer which shunts the non-inductive resistance an amount proportional to the resistance drop. A. H.

305. *Construction of Resistances.* **M. Levy.** (Elektrotechn. Ztschr. 20. pp. 677–679, September 21, 1899. Report read before the Deutscher Elektrotechn. in Hanover.)—An illustrated description of the manufacture of resistances in which the wire is embedded in enamel, and the heat dissipated by numerous ribs on the cast iron framework. E. K. S.

306. *High-Voltage Condensers.* **Lombardi.** (Ind. Elect. 8. pp. 434–436, October 10, 1899. Abstract of paper read by Lombardi, before the National Congress of Italian Electricians at Como.)—On account of the difficulties connected with their construction, condensers have not hitherto been used for reducing the loss in long transmission lines by providing the idle component of the current at the far end of the line. Lombardi has recently succeeded in constructing condensers whose cost is so moderate as to justify their employment on a commercial scale, and which dissipate so little energy that only a slight temperature rise is observed. The condensers consist of sheets of tinfoil insulated with thin sheets of paraffin (mixed with some other ingredients) prepared by a secret process. A condenser capable of working on a 10,000 volt circuit would have a dielectric thickness of 2 mm. A little over 100 kilogrammes of the dielectric would suffice to produce a capacity of 1 microfarad, and the cost of the materials (tinfoil included) would not exceed £14. Experiments carried out by the author have shown that such condensers do not gradually deteriorate when continuously traversed by an alternating current. A. H.

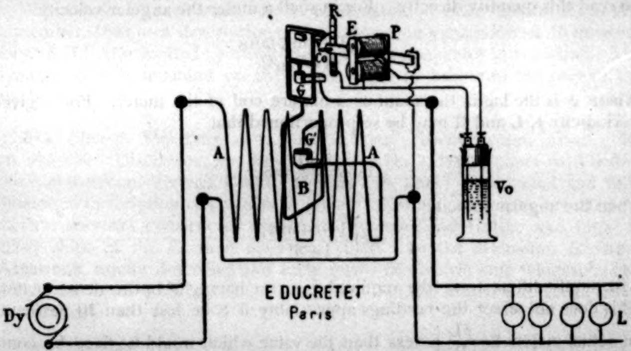
307. *Switches and Circuit Breakers.* **Brunswick, Vedovelli, Zetter, Boucherot, Hillairet, Grosselin, Korda.** (Soc. Int. Élect., Bull. 16. pp. 7–30, and 37–48, 1899.)—These papers form a discussion on the relative merits of various switches for low and high tension circuits.

If interrupters of all kinds are only opened when the current is zero the nature of the metallic surfaces in contacts is immaterial provided the contact is sufficiently good. This is not the case if a current is flowing at the instant of break so as to give rise to sparks or arcs. In this case the choice of the metallic surfaces is a matter of considerable importance. Certain metals and even certain forms of contact surface are better than others in the prevention of the formation of arcs. Recent researches on arcs between metallic electrodes show that certain substances tend to stifle the arc. Zinc tends thus to stifle an arc, as also brass, but to a less extent. For high pressures it is advisable to open switches in oil. W. G. R.

308. *Measurement of Power in Polyphase Systems.* **A. J. Bowie, Jr.** (Elect. World and Engineer, 34 pp. 270–271, August 19, 1899.)—The most common form of three-phase meter at present in use for measuring motor loads is one with a star box. It is not an unusual occurrence for one of the coils of the box to burn out, especially when placed on the wrong side of the switch. In this event the meter will continue to register, since the other coil is alive. If one leg burns out, the meter, if on an induction-motor load, will probably go slightly faster than before; but if the other leg burns out, the meter will slow up very much and in some cases may even run backwards, so that the company will owe the consumer for power which it has furnished.

Meters of this description should be frequently tested to see that both halves of the star box are working. All that is necessary is to see that both legs into the star box spark when disconnected. W. G. R.

309. *Blondlot Meter.* **J. Reyval.** (Écl. Électr. 20. pp. 201–205, August 12, 1899.)—The principle of this meter has already been fully explained in Abstract 1502, 1899. The present paper contains an illustrated description of the details of construction. The connections of the meter and its principal working parts are shown in the sketch, in which AA represents the fixed and B the movable coil of the meter, G and G′ being the two mercury cups by which the current enters and leaves the suspended coil. E is an



electromagnet whose winding is periodically connected across the supply mains. In order to suppress sparking at the contacts, the magnet is provided with a shunt consisting of a liquid resistance V_0 (two wires dipping into water), V is the contact-arm of the movable coil, and closes the circuit of the electromagnet by coming into contact with the spring R; the latter is normally kept slightly deflected by the spring to which the armature of the electromagnet is attached. When the armature is attracted, the spring R is released, and gives an impulse to the swinging coil. C_0 is an arm attached to the armature and carrying a ratchet which drives the counting mechanism (not shown). The main advantages claimed for the meter are: it is capable of starting with a very small current, the frictional resistance of the counting mechanism not impeding the motion, since the mechanism is driven by the shunt electromagnet; there are no permanent magnets, and therefore no change in the constant of the meter need be apprehended. The constant is adjusted by means of two small movable masses attached to the swinging coil, which enable the moment of inertia of this coil to be varied. A. H.

310. *Alternate Current Meters.* (Ind. Élect. 8. pp. 463–464, October 25, 1899, and Elektrotechn. Ztschr. June 9, 1899.)—In order to encourage a high power factor in a supply system the customers' meters should measure the actual power used together with a percentage depending on the idle current. If ϕ be the lag in a consumer's circuit the power

$$P=EC\cos\phi$$

and the idle current$=C\sin\phi$. In order to charge for a given percentage S of this idle current a meter is required whose angular velocity is not simply $=kP$, but

$$=kEC(\cos\phi+S\sin\phi)$$
$$=kP(1+S\tan\phi)$$

By suitable design an ordinary alternate current motor meter can be arranged to read this quantity directly. For in such a meter the angular velocity

$$=kP\frac{1+\tan\psi\tan\phi}{1+\tan^2\psi}$$

where ψ is the lag in the shunt or armature coil of the meter. For a given periodicity p, L and R may be so proportioned that

$$\tan\psi=\frac{pL}{R}=S.$$

Then the angular velocity

$$=kP\frac{1+S\tan\phi}{1+S^2}$$

which only differs from the required form in having S^2 in the denominator. This does not affect the readings appreciably if S be less than 10 per cent. In actual meters $S=\frac{pL}{R}$ is less than the value which would be fixed by commercial considerations. If the armature turns were increased till S=5 per cent. the meter would show increased readings by 7 per cent. with a 60 per cent. load factor, 2½ per cent. with 90 per cent. and 1½ per cent. with 95 per cent. Such a meter would encourage the use of motors, &c., of high power factor. L. B.

311. *Johnson and Phillips Supply Meter.* (Electrician, 43. pp. 604–606, August 18, 1899.)—This is an intermittently integrating ampere-meter, driven by an electrically operated pendulum. The latter is so arranged that it only receives an impulse when its oscillations diminish below a certain amplitude, by means of a hit-and-miss device; the mean power absorbed is said to be not more than one watt. The meter consists of a fine iron wire sucked into a small solenoid by the main current, and actuating an aluminium pointer; once in 30 seconds the pointer is clamped, a feeler is brought against it, and the integrating mechanism is moved through an angle determined by the position of the pointer. The latter is then freed and allowed to take up a new position, according to the current strength, after which the operation is repeated. The pointer moves over a scale graduated in amperes, and visible from the outside of the instrument. The starting current is said to be $\frac{1}{100}$ of the maximum current, and an accuracy of 1 per cent. at all values of the current is claimed. A. H. A.

312. *Electro Pneumatic Signalling.* (Elect. Rev. 45. pp. 679–682, October 27, and 703–704, November 3, 1899.)—The application of this system of railway signalling in the new Boston Union Station is briefly referred to. The signals and points are worked by compressed air and controlled electrically. The system is also in use in the Bishopsgate Goods Yard, London, on the Great Eastern Railway system. Several photographs of the working details are given. The air valves are worked by a solenoid controlled from the signal cabin. An air pressure of 75 lbs. per square inch is employed. The "levers" consist of short crank handles rotating a long bar to which the various switches are attached as required, giving a much more compact and easily operated system, and a wider range of interlocking connections, than can be obtained by mechanical levers. At the Bishopsgate Yard thirty-eight levers are employed requiring 10 cubic feet of air per minute measured at atmospheric pressure. (See 1899, Abstract No. 1283.) L. B.

313. *Cradle Dynamometer.* **A. F. M'Kissick.** (Amer. Electn. 11. p. 409, September, 1899.)—A description of a transmission dynamometer to measure about 5 H.P. transmitted by a belt from an induction motor to a dynamo. The dynamometer is mounted on two knife edges in line with the axis of the machine. A. S.

314. *Electric Ship-Telegraphs.* **A. Raps.** (Elektrotechn. Ztschr. 20. pp. 645–650. Discussion, pp. 650–651, September 7, 1899; paper read before the Elektrotechn. Vereins, Berlin, February 28, 1899.)—A detailed and fully illustrated description is given of a system of ships' telegraphs actuated by electric currents, constructed by Messrs. Siemens and Halske, and fitted to many ships of the German navy and others. In the discussion **Hefner-Alteneck** briefly described the early forms of electric ship telegraphs and **Arldt** the forms constructed by Elliot Bros. and the Allgemeine Elektricitäts Gesellschaft. L. B.

315. *Insulation for High-Tension Lines.* **C. Hesse.** (Elektrotechn. Ztschr. 20. pp. 623–624, August 31, 1899.)—Description of an ingeniously devised insulator which permits the line wire to be in separate sections between each pair of posts. The wire is supported at its ends by metal hooks or fingers which immediately release it in the event of its being broken. There is thus no danger to life. E. K. S.

316. *Aluminium as an Electrical Conductor.* **C. T. Child.** (Elect. Rev. N.Y. 35. p. 133, August 30, 1899.)—The following constants are taken as basis of the calculations in this article :—

	Copper.	Aluminium.
Conductivity................................	100	63
Specific gravity	8·93	2·16
Weights for equal conductivity	100	48
Areas for equal conductivity............	63	100
Diameters of wires for equal conductivity		12·64

The author has calculated from these constants a table showing the equivalent price of aluminium for any price of copper between the two extreme limits of 12 and 20 cents per lb.

This table is also presented in diagram form, with the prices of copper as abscissæ, and the prices of aluminium as ordinates.

The general figures are given below :—

Price of Copper.	Equivalent Price of Aluminium.	Price of Copper.	Equivalent Price of Aluminium.
12	25	17	35·35
13	27·1	18	37·35
14	29·15	19	39·4
15	31·2	20	41·5
16	33·3		

All prices in cents per lb.

The author closes with an expression of his opinion that the use of aluminium for conductors will greatly increase. J. B. C. K.

317. *The Protection of Low-Pressure Circuits from High-Pressure Currents.* **W. B. Reed** and **L. C. Reed.** (Elect. World and Engineer, 34. pp. 649–651, October 28, 1899.)—The methods used at present are classified by the authors : (1) The maintenance of a high insulation on both high-tension and low-tension circuits ; (2) The use of devices to earth, to short-circuit, and to open the affected circuits ; (3) The permanent grounding of one wire of the low-tension circuit.

They point out the objections to these methods, and show by some examples, the unreliability of the last due to the resistance between the earthed main and earth being of uncertain value. They suggest that the earthed-main should be earthed through a set of resistances of certain definite values ; the cutting-out devices to be operated by the current in these earth-circuits when the potential difference between the earthed-main and earth exceeds a certain predetermined limit. E. D. P.

318. *Aluminium Transmission Line.* **F. A. C. Perrine.** (Journal of Electricity, S.F. 8. pp. 41–42, August, 1899. Paper read before the Pacific Coast Electric Transmission Association, San Francisco, June 20–21, 1899.)—Tests of the 43-mile two-phase four-wire power transmission line of aluminium employed by the Standard Electric Company of California are given. The following are the main details. Power transmitted 1,000 kilowatts at 25,000 volts ; diameter of each wire 294 mils. ; weight 420 lbs. per mile ; tensile strength 1,539 lbs. ; resistance 2·11 ohms per mile ; insulation resistance 160,000 ohms to 44 megohms ; capacity 3·35 microfarads ; and self-induction

0·17 henrys per line. The variation of capacity, as well as of insulation, with the state of the atmosphere is noticed. L. B.

319. *Starting Resistances for Induction Motors.* **F. Niethammer.** (Elektrotechn. Ztschr. 20. pp. 604–605, August 24, 1899.)—The induced winding of an induction motor is generally provided with a starting resistance which, in the case of a three-phase winding, is connected star fashion to the winding. Such an arrangement is fairly complicated, and involves a large number of contacts. The author describes a number of starting resistances which are much simpler than those hitherto generally in vogue. In fig. 1 is shown an arrangement for a three-phase induced winding due to Kahlenberg, and used by Siemens and Halske. Fig. 2 may be used in connection with a two-phase winding, and fig. 3 shows another variety of a three-phase starting resistance. In the last case, there is a slight want of symmetry, since when the contact-arm has reached its extreme position, so as to bridge over the last two contacts, one phase is short circuited on itself, while the remaining two are joined in series and short circuited. A. H.

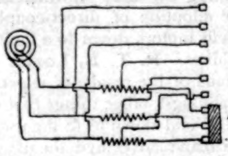


FIG. 1.

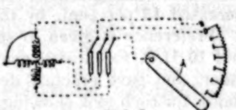


FIG. 2.

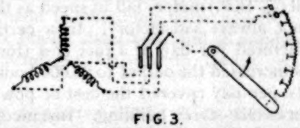


FIG. 3.

320. *Electric Transmission in Steel Works.* (Engineer, 88. pp. 45–46, July 14, 1899.)—This is a description of the electrical plant at the works of the Frodingham Iron and Steel Company, Doncaster. Electromotors are used to drive the line rolls and skids, through worm-gearing running in oil, with a speed reduction of 9·5 : 1. A furnace charging machine is also electrically driven. The motors are of 30 H.P. each, but are capable of working at 80 H.P. intermittently; they are of the enclosed type, with four poles and slotted armature cores. Each motor is governed by a controller, the starting, stopping, and reversing being effected with a single lever. Other motors are in use driving a crane and a slag-crushing mill. The plant is highly spoken of. A. H. A.

321. *Size of Motors for Driving in Workshops.* (Amer. Instit. Elect. Engin., Trans. 16. pp. 168–199, 1899.)—This topical discussion dealt with the question of subdivision of the motor equipment of electrically driven works, from the points of view of capital outlay, economy of power, and convenience. **G. S. Dunn** submitted data and curves showing that the direct saving of power effected by substituting three small motors for one large motor of equivalent power was trifling, but the indirect saving due to the idle periods of machines ranges from 15 to 50 per cent. The cost of three motors compared with that of one is 70 per cent. greater when the total power is 2 H.P., 28 per cent. greater for 50 H.P., and 2 per cent. less for 100 H.P. In at least one-half of the cases met with the question of convenience is paramount, and the gain in this respect far outweighs considerations of cost or economy. As the energy expended costs only from 0·5 to 1·8 per cent. of the value of a finished product, economy of energy is in any case unimportant. The absence of belts confers great benefits on workshops; the output of the Government Printing Office in Washington, the running expenses of which are £2,200 a day, was increased 15 per cent. by the adoption of direct-coupled motors throughout. Preference is given to small motors down to a limit of 5 H.P. for light, and 10 H.P. for heavy, machines. **R. T. E. Lozier** confirmed these statements, and gave practical details of the results of experience with a separate motor for each tool, showing amongst other things that the cost of repairs is small. No general rule can be laid down as to the use of direct-coupled *v.* geared motors. **H. W. Leonard** advocated the use of a four-wire distribution system, giving six different pressures for efficient speed regulation, and described a three-wire system with + or — booster, as well as a motor-dynamo system of delicate control at low speeds. **G. Hall** pointed out that very small ($\frac{1}{10}$ H.P.) motors fall in speed as their temperature rises, and are therefore not always satisfactory. In a certain case, where 14,000 books were manufactured per day, at a fuel cost (for power only) of £9, the adoption of motors increased the output to 22,000 books per day, while an outlay for fuel of £1 14s. per day covered the cost of power, lighting, and operating the elevators in a twelve-storey building. Instances were given of the saving in power due to the abolition of belting, and extreme subdivision of the motors was advocated. **H. B. Coho** described a case where it was preferred to drive 100 sewing machines with separate motors, at heavy cost, in order to avoid liability to break down. **O. Smith** recommended a separate motor to each machine down to a limit of 2 H.P., and gave details of his experience, stating that a 3 H.P. motor could easily work up to 15 H.P. momentarily. **G. S. Dunn** pointed out that H. W. Leonard's system did not apply to cases where constant power with varying torque and speed was required; for this, mechanical gearing was necessary. **A. Williams** emphasised the necessity of co-operation between the makers of motors and of the machines to be driven, and put the lower limit of subdivision at $\frac{1}{2}$ H.P. **J. M. Smith** said that in scarcely any factory are one-third of the machines in operation at one time; the great economy of electrical transmission is due to the stoppage of the motors when the machines are idle. **A. Williams** added a number of data of shaft losses varying from 18 to 68 per cent., and **G. Hill** stated that in numerous tests he had never found less than 50 per cent. loss. A. H. A.

322. *Electric Power in Engineering Works.* **L. Bell.** (Eng. Mag. 18. pp. 69–82, October, 1899.)—Three principles of economy underlie the efficient operation of any machine tool—

1. Keep it working steadily at or near its rated capacity.
2. Keep down friction, backlash, and lost motion of every kind.
3. Keep down manual labour.

To maintain a good load factor, the plant should have no periods of inactivity and no parts running idle. Economy is gained by using a separate motor for each operative unit (for example, a group of a dozen automatic screw machines) and not a motor for each individual machine. Portable tools are recommended, equipped with their own motors, thus minimising transportation of work to and fro to the different shops. Enclosed arcs are advocated, naked arcs being too glaring and casting sharp shadows. M. O'G.

323. *Electrical Machinery in the United States Navy.* **A. D. Adams.** (Engineer, 88. pp. 233–234, September, 1899.)—The author points out various errors in the arguments which have been put forward, both for and against the use of electrical transmission of power to auxiliary machinery, and making liberal assumptions finds that electrical methods would save 67 per cent. of the steam at present consumed, or 80 lbs. steam per B.H.P. hour at the motors. The saving in weight of boilers and feed water due to this fact is generally overlooked; taking this into account, in a case where machines of 2,400 H.P. are installed, of which half are in use at one time, the total weight of steam equipment is 876,000 lbs., of electrical equipment 612,900 lbs., showing a gain of 263,100 lbs. with ordinary apparatus. When specially designed machinery of lighter construction is employed, such as is already on the market, giving 1 E.H.P. per 75 lbs. weight of engine and dynamo, the saving in weight is increased to 498,000 lbs., or more than 50 per cent. Further, it is shown that the extra cost of electrical equipment would be paid for out of the coal saved in less than seven months. Full details are given of the assumptions made in obtaining these figures. The electrical plant on board the *Iowa* is briefly described, and a number of arguments adduced regarding the advantages of electric cables as compared with steam pipes, &c. A. H. A.

324. *Electricity in Marine Work.* **S. D. Greene.** (Cassier, 16. pp. 207–222, July, 1899.)—This article deals generally with various applications of electricity to shipyard service and the minor functions on board ship, with many illustrations. (See also 1899, Abstract No. 759.) A. H. A.

325. *A 250 H.P. Electric Heating Plant.* (Elect. World and Engineer, 34. pp. 337–339, September 2, 1899.)—This paper describes the application of electric heating in a large hat manufactory in New Jersey, the heat being applied to irons, moulds, &c., for shaping and finishing felt hats. Although the cost of a heat unit generated electrically is necessarily greater than if generated by other means, the waste in the application of electric heat is a minimum, while in localisation, ease of control and cleanliness, it is superior to any other method; these advantages have made the installation under consideration a great success, and point to further applications of electric heating in other industries. M. G. W.

326. *Electrical Dredges.* (Elect. World and Engineer, 34. pp. 517–521, October 7, 1899.)—This is a well-illustrated description of a dredger built for the river Volga, which is electrically propelled and controlled. A 600 kw. three-phase generator is driven by a triple expansion engine, and supplies power to two motors in the stern and two in the bow, each of 125 H.P., and driving a 4-foot screw propeller, as well as to two 30 H.P. motors controlling the pontoon line. The motors are all of the induction type, and are controlled from the pilot-house. The dredge is capable of removing 7,000 cubic yards per hour. A. H. A.

327. *British Overhead Electric Travelling Cranes.* **A. G. Parrott.** (Cassier, 17. pp. 14–20, November, 1899.)—In mechanically driven travelling-

cranes a large proportion of the power applied is absorbed in merely moving the rope or revolving the shaft, and this consumption of power is constant whether the crane is working or not. Even in the busiest shops cranes are seldom engaged more than 40 per cent. of the working hours, the remaining time being occupied in preparing loads and adjusting slings. The electrically driven crane is superior in this respect to the mechanically driven one, and also in the facility with which the transmission of power can be made. The various advantages of electric cranes are discussed in simple language, and the practice of makers with regard to motors, switches, speeds, &c., are detailed. With the introduction of the high speeds of crane-travel it has been found necessary to increase the strength of the girders; the top flange should be designed so as to easily resist lateral strains which occur by suddenly stopping and starting the crane when fully loaded. A. S.

328. *Electric Canal Haulage.* **G. Klingenberg.** (Elektrotechn. Ztschr. 20. pp. 541–546, August 3, 1899.)—A description of a series of experiments made by Siemens and Halske in electric haulage on the Finow Canal. Two systems were tried—that of Lamb, and a new one designed by Köttgen. One kilometre of canal was equipped with the necessary overhead lines, continuous current at 500 volts being employed in each case. In the Lamb system a 5 H.P. series motor is carried in a truck weighing one ton in all and runs on an overhead cable. Owing to the strains set up it was found impossible to support this cable on insulators, and a second line had to be erected to supply the current.

The barges are towed by ropes as usual. Owing to the suspension of the motor, the construction of curves offers great mechanical difficulty. The supporting wire is subjected to severe bending strains, and an accident of any kind causes a serious interruption in the traffic owing to the great weight of the suspended motor. The compensating advantage lies in the fact that the tow-line is carried well overhead.

In the Köttgen system a small electric locomotive is employed of some two tons weight. The wheels on one side only are driven, these carrying 85 per cent. of the weight of the locomotive, thus giving stability against the side strain of the tow-line. The other wheels run either on a light rail or on the paved tow-path.

A rack system was tried but abandoned in favour of simple adhesion. The normal speed is three miles per hour when exerting a tractive force of 12 cwt. A series motor is used, and hence a much higher speed is attained when the loco. is running light. Details of the experiments and a summary of the advantages of electric haulage are given. L. B.

REFERENCES.

329. *Progress of Primary Batteries in the last Twenty-five Years.* (Elektrochem. Ztschr. 6 pp. 148–153, October, 1899.)

330. *Description with Particulars of Sizes and Results of Tests on Pescetto Accumulators.* **J. Reyval.** (Écl. Électr. 21. pp. 137–138, October 28, 1899.) (See Abstracts, 1898, No. 431, and 1899, No. 1245.)

331. *Aron Energy Meter.* **M. Aliamet.** (Électricien, 17. pp. 337–339, June 3, and pp. 354–360, June 10, 1899.)—This is a description of the latest form of the Aron meter.

GENERATORS, MOTORS, AND TRANSFORMERS.

332. *Low-voltage Dynamos.* **E. K. Scott.** (Electrician, 43. pp. 904–905, October 20, 1899.)—The author discusses the design of dynamos for electrochemical work with special regard to the difficulty of collection, and points out the advantages of the internal field type with ring armature, the conductors on the external periphery of which are used as commutator bars. The large brush surface obtained permits of the use of cheap carbon brushes—an important point; in one case where the renewal of copper brushes cost £20 to £40 per month, the substitution of carbon reduced the outlay to a nominal figure. The saving in cost of construction of the internal-field machine is also referred to.

For smooth-core armatures which are liable to short circuits, the Oerlikon Company uses brass discs at intervals in the core, which are perforated to carry the conductors and hold them in place. A. H. A.

333. *Brush Multicircuit Arc Dynamo.* (Amer. Electn. 11. pp. 436–437, September, 1899.)—Three circuits of 42 lamps each are run off a 125 light Brush arc-light dynamo. Each circuit is connected between the positive brush of one armature section and the negative brush of the next, so that, although the three circuits are really in series, there are only 2,100 volts in each. The current is controlled by a new form of oil regulator, which consists of an oil pump driven off the shaft by a belt supplying oil through a two-way valve to a rotary piston which works the rheostat arm and brush-rocking mechanism. The valve is worked by a solenoid in the main circuit, with an excess current it admits oil to one side of the piston, and with a current less than normal, to the other side. The valve and ports are made so that in the normal position the oil leaks past both ports. R. B. R.

334. *Arc-Machine Regulation.* **H. F. Watts.** (Elect. World and Engineer, 34. pp. 157–158, July 29, 1899.)—The author advocates the use of the Thomson-Houston regulator on modern arc-lighting dynamos. W. G. R.

335. *Armature Reaction in Dynamos.* **R. V. Picou.** (Soc. Int. Élect., Bull. 16. pp. 160–173, 1899.)—Instead of attributing the fall of potential between the brushes of a dynamo as the load increases to a demagnetising effect of the armature currents (in addition, of course, to a fall of potential due to the resistance of the armature itself), the author prefers to attribute it to an increase in the reluctance of the magnetic circuit. Whichever explanation is given the fall of potential is due to a diminution of the useful flux through the armature. The change in the reluctance is due to the deformation which the magnetic field undergoes on account of the effect of the armature current, and is constant so long as the lead of the brushes is less than half the interpolar angle; whence the fall of potential is independent of the lead of the brushes and cannot therefore be due to the opposing ampere turns of the armature. The author supports his theory by proving experimentally that the fall of potential between the brushes is independent of their lead and then showing by calculation that the effect of the increase of the reluctance due to the deformation of the magnetic field agrees with the experimental results. The effect of the armature current is to modify the distribution of the magnetic flux. These modifications are as follows: (1) In the magnets the lines of force undergo a slight increase of length. In the yoke and limbs there is no change of induction in any way whatever; but in the pole-pieces in the neighbourhood of the air-gap the induction varies from point to point and consequently the permeability also. (2) In the air gap the magnetic path is lengthened. (3) In the armature there is little or no change of permeability, but the mean length of the magnetic path is increased.

W. G. R.

336. *Armature Reaction in Alternators.* **A. Blondel.** (Comptes Rendus, 129. pp. 586-589, October 16, 1899.)—Considering the case of a polyphase alternator symmetrically loaded, the author points out that the actual armature reaction corresponding to a given phase displacement may be regarded as made up of (1) an opposing magnetic flux due to the idle component of the current; (2) a cross-flux due to the load component. So long as the magnetisation is well below saturation, the effect of armature reaction may be expressed in terms of two coefficients of self-induction, l (corresponding to load current) and l^1 (corresponding to idle current), by the vectorial equation

$$\overline{E_a} = \overline{r}I + \overline{lpI\cos\psi} + \overline{l'pI\sin\psi},$$

where E_a is the drop of potential due to armature resistance and reactance, r the resistance of the armature, and ψ the phase-difference between the E.M.F. and current. The vectors $\overline{lpI\cos\psi}$ and $\overline{l'pI\sin\psi}$ are in quadrature with the currents $I\cos\psi$ and $I\sin\psi$ respectively, while $\overline{rI}$ is in phase with I. In cases where the permeability can no longer be regarded as constant, we must, instead of considering l', determine the magnetomotive-force corresponding to it, and compound this with the magnetomotive-force due to the field winding.

A. H.

337. *Armature Reaction in Alternators.* **A. Potier.** (Comptes Rendus, 129. pp. 637-640, October 23, 1899.)—Referring to Blondel's paper (see preceding Abstract), the author states that the assumption by that writer of two different coefficients of self-induction for the armature is intended to emphasise the fact that the inductance of the armature varies according to its position in the field, and is a periodic function of frequency double that of the E.M.F. Taking the general differential equation of current—

$$Ri + \frac{d}{dt}(Li) = E\sin pt,$$

the author considers the special case in which $L = \frac{L_1}{1 - 2\alpha\cos 2pt}$, and obtains a solution in the form of a convergent series arranged according to power, of α. If, therefore, the E.M.F. follows the simple harmonic law, and L is variable, the current can no longer be assumed to be a simple harmonic one—an assumption implied in Blondel's treatment of the subject. The author further obtains a solution of the differential equation of current when the E.M.F. is expressed by a Fourier series, and $L = L_1/(1 - 2\alpha\cos 2pt - 2\beta\cos 4pt - 2\gamma\cos 6pt - \ldots)$

A. H.

338. *Sparkless Running of Dynamos.* **H. Isler.** (Elektrotechn. Ztschr. 20. pp. 714-716, October 12, and 732-734, October 19, 1899.)—In this elaborate paper the author seeks to establish criteria whereby the behaviour of a machine

all of whose constructional details are accurately known may be estimated as regards sparking. The differential equations of the current in the short-circuited coil, and the currents passing to or from the commutator segments, are first developed. From these equations the author deduces a relation connecting the mean induced E.M.F. during the period of short circuit with the armature current, the inductance of the coil, and the time of the short circuit—on the suppositions that the current-density under the brush remains uniform, and that the induced E.M.F. obeys the straight-line law. By means of this relation, and from the known intensity in the air-gap, it is possible to predetermine approximately the lead of the brushes. The calculation of the brush contact resistance and the inductance of the coil in various cases is next considered. The author points out that a machine having a very small brush lead is not necessarily a satisfactory one, since sparkless commutation may be only possible within very narrow limits, and the brushes may require careful adjustment. He then proceeds to develop some other formulæ, which furnish further tests as to the non-sparking quality of a machine. A long table, containing various data of a number of actually constructed machines, is appended to the paper. A. H.

339. *Paralleling of Gas-driven Alternators.* **G. Dettmar.** (Elektrotechn. Ztschr. 20. pp. 728–730, October 19, 1899. Read before the 7 Jahresversammlung des Verbandes Deutscher Elektrotechniker at Hanover.)—The principle of the device patented by the author has already been briefly explained in Abstract No. 1273 (1899). The magnetic brake consists of a powerful electromagnet whose pole-pieces are placed in close proximity to the rim of the engine fly-wheel. The braking effect is due partly to hysteresis and partly to the powerful eddy-currents induced in the rim. The magnet coil is connected in series with a regulating resistance which enables the load to be varied. Such an electromagnetic brake costs less than an artificial load of wire resistances. It is in use at some lighting stations in Germany, and the author cites a case in which two gas-driven alternators are paralleled without any noticeable disturbance by means of such a brake, whereas any attempt to parallel them without it gives rise to very heavy equalising currents and consequent fluctuations in the P.D. of the mains. A. H.

340. *Hunting of Paralleled Alternators.* **P. Boucherot.** (Écl. Électr. 21. pp. 121–127, October 28, 1899.)—Referring to Kapp's article on this subject (see 1899, Abstract No. 1085), the author points out that as far back as 1892 he had, in *La Lumière Électrique*, vol. xlv., given an explanation of the see-sawing action which is sometimes observed to take place between paralleled machines. A portion of the original article is reproduced, and the author then gives the following approximate formula for the period of oscillation T of the alternator rotor :

$$T = 2\pi n\sqrt{\frac{20\pi M}{fEI}}$$

in which n stands for the revolutions per second, M for the moment of inertia of the rotor (kilogramme and metre as units), f for the frequency, E for the 'bus bar P.D., and I for the short-circuit current of the alternator corresponding to normal excitation. This formula agrees with that given by Kapp.[1] In

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[1] The formula as originally given in Abstract No. 1085, 1899, is wrong on account of a typographical error in Kapp's paper ; the correct expression is—

$$2\pi\sqrt{\frac{vdm}{0{\cdot}102\pi ei}}.$$

dealing with two-phasers, 2EI, and in dealing with three-phasers, $\sqrt{3}$EI must be substituted for EI in the above formula. In the case of a three-phaser, E stands for the P.D. between any 2 terminals, and I for the short-circuit current flowing towards or from each terminal. The author points out that T is not quite constant, but decreases with the load, and this decrease may, in alternators with powerful armature reaction, amount to as much as 20 or even 25 per cent. In order to avoid see-sawing the author recommends making T as large as possible in comparison with the periodic time of the impulses of the prime mover (avoiding ratios of 1, 3, 5, &c.), preferably by making M large. A. H.

341. *Hunting of Paralleled Alternators.* **A. Blondel.** (Écl. Électr. 21. pp. 215-216, November 11, 1899.)—The author states that almost simultaneously with Boucherot (see preceding Abstract), he had, in *La Lumière Electrique*, vol. xlvi., given a solution of the problem of the see-sawing of paralleled alternators. The formula obtained by him is

$$T=\frac{2\pi}{P}\sqrt{\frac{9{\cdot}81Mp}{E\cos\theta(I\sin\phi-I_e\sin\psi)}}$$

where T is the period of the oscillation; P=number of like poles on one side of armature; M=moment of inertia of rotor (kilogramme and metre as units); $p=2\pi\times$frequency; E=E.M.F.; θ=angle of oscillation; I=short-circuit current corresponding to normal excitation; I_e=actual current; $\tan\phi=\frac{pl}{r}$; $\tan\psi=p\frac{2L+l}{2R+r}$, where r, R stand for the resistances, and l, L for the inductances, of the alternator armature and the external circuit respectively. If instead of two machines there are m of them, then $\tan\psi=p\frac{mL+l}{mR+r}$. This formula is more general than those given by Boucherot and Kapp, and includes the latter as special cases ($\cos\theta=1$; $\sin\psi=0$). The author points out that since I_e increases with the load, the value of T would, at constant excitation, *increase with the load*. It is only on account of the fact that with increasing load the excitation (and therefore E) has to be increased in order to maintain a constant P.D., that T decreases with the load—the effect of increased excitation more than counter-balancing the effect due to the increase in I_e. A. H.

342. *Vector Diagram of Paralleled Alternators.* **C. F. Guilbert.** (Écl. Électr. 20. pp. 321-328, September 2, 1899.)—The author considers the graphical treatment of the following problem: two alternators being coupled in parallel, and the P.D. across their terminals being maintained constant, to find the law connecting the E.M.Fs, currents and powers of the two machines when any one of these quantities is made to vary. A number of vector diagrams illustrating various particular cases accompany the paper. A. H.

343. *Divided Closed-Coil Windings.* **G. Ossanna.** (Zeitschr. Elektrotechn. Wien. 17. pp. 347-353, June 25, 1899.)—The author considers how an ordinary closed-coil winding of the Gramme or drum type may, by opening it at a number of points and then suitably connecting the different groups of conductors, be adapted to various special purposes. Let an armature with a given number of uniformly distributed external conductors be supposed to revolve in a two-pole magnetic field having a sine distribution round the armature periphery. Each conductor then becomes the seat of an alternating

E.M.F. obeying the sine law, but at any given instant the phases of the various E.M.Fs. are different. These E.M.Fs. may be represented in a vector diagram by drawing a circle and inscribing in it a regular polygon of as many sides as there are conductors. The projections of the sides of the polygon (which is supposed to revolve synchronously with the armature) on a fixed straight line will then give the instantaneous values of the various E.M.Fs. The resultant E.M.F. due to any group of conductors, such as that included between points I and I′ (fig. 1), is represented in magnitude and phase by the corresponding chord II′. The following groups of windings are considered by the author: (A) Windings by means of which three-phase currents may be obtained of an E.M.F. other than that which alone would be possible if the winding remained closed. Examples are shown in figs. 2 and 3. In both cases the closed winding is cut open at three points 120° apart (I, II and III in fig. 1). In fig. 2 the ends I′, II′ and III′ are joined together, and the ends I, II and III are connected to slip-rings from which three-phase currents may be obtained. This gives, in fact, an ordinary "star" winding.

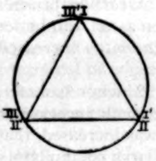


FIG. 1.

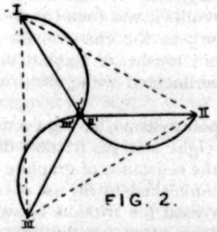


FIG. 2.

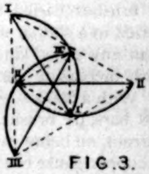


FIG. 3.

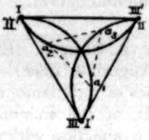


FIG. 4.

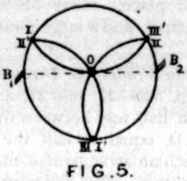


FIG. 5.

The E.M.F. between any two mains is here $\sqrt{3}$ times that which would have resulted if the winding had remained closed. Fig. 3 shows an arrangement whereby the same armature may be made to supply two distinct three-phase circuits, viz., a high-voltage motor circuit connected to I, II, III, and a low-voltage lamp circuit connected to I′, II′, III′. (B) Windings by means of which a high starting torque may be obtained in the rotors of induction motors *without the use of starting resistances*; this higher torque is obtained by reducing the E.M.F. in the induced winding at the moment of starting, so as to necessitate a much greater slip than the normal one for the production of a given current. An example is shown in fig. 4, in which a_1, a_2, a_3 are three symmetrically placed points in the three arcs of the winding; these three points are at starting connected together, and the slip required to produce a given torque is then $\left(\frac{\text{I II}}{a_1\, a_2}\right)^2$ times greater than that corresponding to a connection of I, II, III; this last connection is established when the motor has run up to speed, and after the points a_1, a_2, a_3 have been disconnected. (C) This group of windings applies to cases in which the armature is provided with two independent windings, one of which is connected to a commutator in the usual way. An example is shown in fig. 5, in which B_1, B_2 are the brushes of the closed-coil winding, whilst the points I, II, III of the divided winding are connected to points of the same potential in the closed-coil winding. The point O at which the six sections of the divided winding meet possesses the property that it always halves the E.M.F. between the brushes. Hence by connecting O to the balancing wire of a three-wire system, the machine may be used either as an equaliser or as a three-wire generator, and the cross-section of the conductors in the divided winding need only be large enough to enable them to carry the equalising current. Besides the examples shown in figs. 2–5, the paper contains a very large number of diagrams showing various other arrangements of a divided closed-coil winding. A. H.

344. *Resistance of Dynamo Brushes.* (Elect. World and Engineer, 34. pp. 417–419, September 16, 1899.)—A series of experiments made by R. B. Tibbals, L. Lowenberg, and W. G. Burns on a 35 kw. dynamo is described. With other results it was found that—the resistance of all kinds of brushes varied inversely as the current; the friction of carbon brushes varied in a similar manner; brushes of Babbitt metal, when oiled, ran better than any other kind experimented with; the friction of the latter increased with increasing current.

With a 200 kw. eight-pole dynamo, having a commutator 32 inches diameter, 268 bars, 64 brushes in eight sets, the friction diminished with increase of current, oil being used; the resistance of graphite brushes was increased, that of copper-gauze brushes diminished, by the use of oil. With large commutators the application of oil increased the friction, but with a small commutator the contrary took place. Many other conclusions, of minor importance, are given in the paper, and a large number of experimental curves. A. H. A.

345. *Weston Winding for Three-wire Dynamos.* **A. Sengel.** (Elektrotechn. Ztschr. 20. pp. 525–527, July 27, and 548–550, August 3, 1899.)—By placing a third brush half-way between the main brushes of a dynamo, two circuits, each at a P.D. equal to half the terminal P.D. of the machine, may be supplied. Such an arrangement may be used in connection with a three-wire distributing system. The difficulty due to sparking at the intermediate brush may be overcome in various ways. The author points out that armatures provided with a Weston winding—*i.e.*, one consisting of two (or more) independent closed windings, the commutator segments of the one winding being sandwiched in between those of the other—are especially suitable for this purpose. The main brushes of the machine must in this case cover as many commutator segments as there are windings. By making the third brush only wide enough to cover a single segment, short-circuiting of single coils by this brush is prevented. When running on open circuit a certain amount of sparking at the intermediate brush still takes place, on account of the differential action between the two branches of the winding which connect each main brush with the intermediate one. The author made the singular discovery that the amount of sparking is dependent on the polarity of the pole-piece under which the intermediate brush is placed, a good deal more sparking taking place when the current passes from the brush to the receding commutator segment than when the reverse arrangement is adopted. When the machine is loaded on one side only, its behaviour with regard to sparking depends on whether the load circuit is between the intermediate brush and the main brush in advance of it, or the intermediate brush and the main brush behind it. In the former case the sparking decreases with increase of load up to a certain limit at which it practically vanishes and beyond which it reappears. In the second case, the sparking steadily increases with the load. These effects may be explained by considering the armature reaction and current distribution in each case. The author concludes from his experiments that when carbon brushes are used, machines constructed on the above plan are capable of giving good results when used on a three-wire network on which the want of balance does not exceed 20 per cent A. H.

346. *Wagner Single-Phase Motors.* (Amer. Electn. 11. p. 299, June, 1899.)—A description of tests of a 5 H.P. Wagner Electromotor carried out by R. B. Owens, University of Nebraska. The construction of the motor is not described, but it consists of a motor started by placing the armature with commutator and brushes, in series with a field excited by the inducing coil, thus forming a series motor. When run up to speed the armature coils are short circuited, and the motor runs as an induction motor. No results are given of the current, torque, or power factor at starting. When running, the motor gives a maximum efficiency of 78 per cent. and a power factor of 88 per cent. Curves are given showing the variation of these with variations of terminal pressure. The frequency of supply is not stated. The efficiency of the motor when hot was 2 to 3 per cent. higher than when cold, stated to be due to a reduction of iron losses. Ll. B. A

347. *Induction Motors.* **C. A. Carus-Wilson.** (Elect. Rev. 45. pp. 697–698, October 27, 1899. Lecture delivered before the Royal Institution, April 28, 1899.)—The theory of the alternating current motor was illustrated in an interesting way by aid of the oscillograph, the author showing that the law of force variation, with synchronously varying field and current, was such that two series of impulses at right angles gave a uniform impulse when acting together. It was thus possible to construct an alternating current motor in which the sum of the turning moments on the shaft was a constant quantity; the well-known induction motor giving such a result.

The rotating magnetic field of the induction motors was illustrated by an experiment in which a small permanent magnet carrying a mirror was centred upon a vibrating rod placed between two pairs of electromagnets. When two opposite magnets were excited the mirror vibrated between them and reflected a spot of light on to the screen, tracing out a vertical line. When the second pair of opposite magnets was excited the spot traced out a horizontal line of equal amplitude. Both sets were then excited together by currents in step with each other, with the result that the spot vibrated in a line, making an angle 45° with the former lines of vibration. When, however, the exciting currents were made to differ by one-quarter of a period the spot of light reflected from the mirror described a circle, showing that the magnetic field produced by two magnets set at right angles, and excited by two currents differing by a quarter of a period, is of uniform intensity and rotates at a uniform rate. E. K. S.

348. *Heyland Single-Phase Motors.* **A. C. Eborall.** (Elect. Rev. 45. pp. 510–513, Sept. 29, 1899.)—The Heyland motors differ but little with regard to general design from other well-designed motors of the induction type. It is in the method of the stator windings that novelty is claimed for them. The starting coil has few turns, while the running coil is divided into sections which are successively cut in as the speed of the rotor increases, one section only being used at the instant of start.

The rotor is wound in the tri-phase star fashion, the free ends being connected to three collector rings rigidly attached to the rotor shaft, but electrically insulated from it and from each other.

The accompanying table gives particulars of these motors in sizes varying from $\frac{1}{10}$ to 100 H.P. for 50 cycles and 100 to 800 volts.

B.H.P.	Revs. per minute.	Power factor. Per cent.	Efficiency Per cent.	Weight. Lbs.	B.H.P.	Revs. per minute.	Power factor. Per cent.	Efficiency Per cent.	Weight Lbs.
$\frac{1}{10}$	1,500	55	50	66	20	1,000	82	85	1,100
$\frac{1}{2}$	1,500	65	65	143	40	750	85	89	2,640
1	1,500	70	70	154	60	750	85	90	3,500
5	1,500	75	80	440	80	750	85	90	4,400
10	1,000	80	82	660	100	750	85	91	5,000

The motors are designed on the following lines :—

1. Temperature-rise after eight hours at full load will not exceed 40° C.

2. Drop of speed varies from 10 per cent. in the smallest sizes to 3 per cent. in the largest motor.

3. All motors have a loading limit of $1\frac{1}{2}$ times the full load.

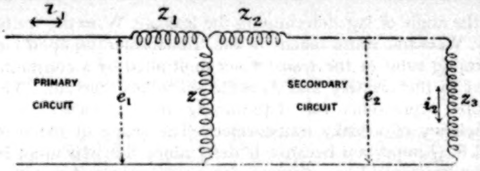
4. The motors are designed either to start up with a torque equal to full load, the current consumption being twice the full load current, or else to start with a torque equal to two-thirds of that at full load, the current being $1\frac{1}{2}$ times the full load current. W. G. R.

349. *Frictional Losses in Induction Motors.* **R. Braun.** (Elektrotechn. Ztschr. 20. pp. 685–687, September 28, 1899.)—The following methods may be used for determining friction losses in induction motors: (1) The simplest is to measure the power absorbed by the motor when running light, then suddenly to open-circuit the induced winding and take another wattmeter reading as quickly as possible. The difference of the two readings is practically equal to the frictional loss. (2) The second method consists in finding the retardation curve of the rotor, and from the moment of inertia of the rotor and its retardation finding the required frictional loss. (3) A small auxiliary motor whose efficiency is known may be used to drive the rotor. (4) Very reliable results may be obtained by measuring the brake-power w (in watts) at the motor pulley, the percentage slip s corresponding to this, and the slip s_0 when running light. If w_0 stand for the required frictional loss in watts, then the author shows that—

$$w_0 = \frac{w}{\frac{N^2}{N_0^2} \cdot \frac{s_0(100-s)}{s(100-s_0)} - 1}$$

where N and N_0 stand for the total magnetic flux through a rotor winding when loaded and running light respectively. The author finds that the mean value of N^2/N_0^2 for well-designed motors is 0·9. A number of actual tests are described illustrating the use of this method, which is very convenient as a check on results obtained by method (1). A. H.

350. *Predetermination of Drop in Transformers.* **A. E. Kennelly.** (Elect. World and Engineer, 34. pp. 343–344, September 2, 1899.)—Transformer calculations are much simplified by supposing the secondary circuit replaced by an equivalent circuit giving a ratio of transformation equal to unity. If n is the actual ratio of transformation (or ratio of secondary to primary turns), then in effecting the reduction mentioned all secondary P.Ds. must be divided by n, all secondary currents multiplied by n, and all secondary resistances, reactances or impedances divided by n^2. We may next suppose the primary and secondary circuits conductively connected as in the fig., where z_1=impedance corresponding to primary leakage flux, z=impedance corresponding to flux common to the two coils, z_2=impedance corresponding to secondary leakage flux, z_3=impedance of secondary load, each impedance being expressed as a complex quantity ($=r+ix$, where $i^2=-1$). If e_1 stand for the primary and e_2 for the secondary P.D. respectively, then we have—



$$\frac{e_2}{e_1}=\frac{z_3}{z_1+z_2+z_3+z_1\left(\frac{z_2+z_3}{z}\right)} \qquad (1)$$

In most cases, z is so large in comparison with the other impedances, that the last term in the denominator of the right-hand fraction may be neglected, and we may write—

$$\frac{e_2}{e_1}=\frac{z_3}{z_1+z_2+z_3} \qquad (2)$$

In order to find e_2/e_1 for any given load, we must know z_1, z_2 and z_3. The latter is known from the nature of the load. To find z_1+z_2, we short circuit the 2^{ary} coil through an ammeter, and measure the 1^{ary} P.D., e_1, required to produce a current i_2 in the short-circuited secondary. Then $z_1+z_2=\frac{e_1}{i_2}$. Since the sum of the resistances r_1+r_2 is known, we easily find the sum of the reactances $i\,(x_1+x_2)$, so that z_1+z_2 is completely determined. Equation (2) then enables us to find the drop for any given load. A. H.

351. *Magnetic Leakage in Transformers.* **A. Russell.** (Electrician, 42. pp. 567–569, 603–604, 788–789, and 823–824, 1899.)—In this series of four articles the author develops formulæ for ascertaining the magnetic leakage in transformers with varying loads. The author points out the importance of including magnetic leakage in the calculation for the design of transformers, and also the influence of magnetic leakage on the efficiency of transformers. The common method of estimating this leakage by subtracting from the open circuit secondary voltage, the secondary voltage at full load and the copper drop is not satisfactory, owing to the small differences concerned. The author is of opinion that the measurement of angle of lag of the secondary current behind the E.M.F., caused by the driving flux in the core, is much more useful in determining the leakage. This angle varies with the shape of the E.M.F. waves, and is proportional to the current in the secondary coils.

The author proceeds to give a vector diagram of the various voltages in the primary and secondary circuits of a loaded transformer, and deduces from this the angle of lag due to the leakage above mentioned. He then develops from the diagram the expressions for the sine, cosine, and tangent of the angle of lag in terms of the angles of lag in the primary and secondary circuits and the currents in the same. One development of these formulæ is as follows:—

$$\cos \alpha = \frac{W_1 - W_0}{n V_1 A_2}$$

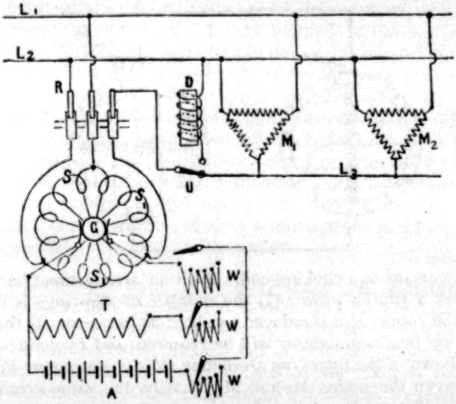
Where α = the angle of lag determining the leakage, W_1 = the watts given to the primary, W_0 = the watts taken by the transformer, on open circuit, n = the transforming ratio of the transformer multiplied by a constant, V_1 = the volts applied to the primary and A_2 = the secondary current. The author next develops expressions for determining the secondary voltage, and also the efficiency of a leaky transformer. The shape of the wave of the applied E.M.F. is important because it determines the maximum induction, and hence the hysteresis loss. Curves with a high centre of gravity generally produce less induction in the core than curves whose centre of gravity is lower. The author calls attention to other experimenters in this field, and particularly to Roessler's experiments. The figures obtained by this expert are then analysed by the author with the formulæ obtained earlier in the articles. Thus with one transformer supplied by a Ganz alternator with pointed curves the lag due to leakage was found to be 2·1 degrees per ampere of secondary current. With the same transformer supplied by a Wechsler alternator with rounded curves the angle of lag was only 1·1 degree per ampere of secondary current. The frequency in each case was the same. The author also analyses Fleming's test on a Swinburne hedgehog transformer, where the leakage was naturally very much greater. R. W. W.

352. *Transformer Economy.* **F. H. Leonard, Jr.** (Canad. Elect. News, 9. pp. 154–155, July, 1899.)—A good summary of known factors influencing the economy of transformers in practice. Reasons are given in favour of the shell type as against the core type. In regard to the ageing of transformer cores, it is stated that, three years since, one of the largest firms in the States had to take back every transformer supplied four months before to a large central station, owing to the rapid increase in core losses, which, in some cases, had actually doubled. The new cores supplied showed no apparent ageing after nine months. Apparently two lots of iron from the same manufacturers may exhibit differences of 10 or 20 per cent. in the core loss factor. Hence the importance of careful tests in factories. W. E. S.

353. *Motor Transformer for Charging Small Accumulators for Automobiles.* **A. Soulier.** (Ind. Élect. 8. pp. 392–394, September 10, 1899.)—A small continuous-current transformer for charging the cells of petrol-driven automobiles. It is a single-core machine weighing only 9·6 kg., with two windings, one receiving current at 110 volts and the other furnishing low-pressure current for three, four, or five cells. The secondary winding consists of only one bobbin, so that the current supplied is practically rectified current; this variable current has, however, been found to answer well enough in practice. E. K. S.

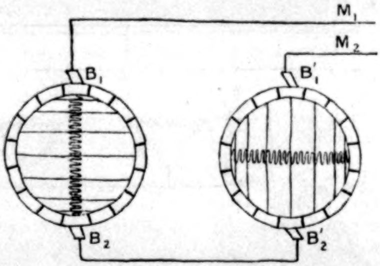
354. *Starting Device for Synchronous Phase-Transformer.* (Elekt. Runds. 16. p. 221, July 1, 1899.)—The arrangement of connections (used by Schuckert

and Co.) is shown in the accompanying sketch, in which L_1, L_2 are the single-phase supply mains, and M_1, M_2 three-phase induction motors connected between L_1, L_2, and a supplementary main L_3, which receives current from the windings S_1 of the phase transformer. The latter may take the form of an ordinary rotary converter, and will run as a synchronous motor when supplied with single-phase current, developing the phase-displaced currents required by the motors. Two methods of starting the phase transformer may be used. The first consists in producing a phase-displacement between the currents in S and those in S_1 by means of a choking-coil D, so as to obtain a rotating field in the armature; the field coils T being short circuited the transformer will start. But since it could never be brought up to synchronous speed by this method, a device for temporarily halving the number of field-poles is provided; the transformer may then be run up to a speed above synchronism, the current switched off, the normal field connections restored, the current switched on at synchronism, and the field excited. In order to prevent sparking when the transformer is self-exciting, a steadying secondary battery is used. This latter, however, also provides another method of starting, by enabling the transformer to be run up to synchronous speed as a simple continuous-current motor. A. H.



355. *Study of Rotary Converter.* **K. Pichelmayer.** (Elektrotechn. Ztschr. 20. pp. 697–701, October 5, 1899.)—The paper contains a number of interesting curves showing the E.M.F. and current waves under various conditions of working, and curves showing the field distribution. All the results given were obtained experimentally. A. H.

356. *Rectifiers.* **L. Kallir.** (Zeitschr. Elektrotechn., Wien. 17. pp. 460–464, September 3, 1899.)—The author describes some modifications of the Hutin and Leblanc *panchahuteur* (see 1899, Abstract No. 505), which have certain advantages over the latter. In the accompanying figure, which is a purely diagrammatic representation of the arrangement, the wavy line represents the secondary winding of a stationary transformer. The winding is divided into sections, the number of turns in a section varying according to the sine law. From the points of junction of consecutive sections connections are established, by means of slip-rings and brushes, with the segments of a commutator, after the manner shown in the sketch. The slip-rings and commutator are driven at the speed of synchronism by means of a synchronous motor. If the supply is a single-phase one, then only one commutator will be required. By means of two brushes, B_1 and B_2, placed in such a position that when the secondary E.M.F. is at its maximum the whole of the secondary turns are in circuit, a pulsating uni-directional current may be obtained in a circuit connected across the brushes. The pulsations may be damped by means of a choking-coil. Such an arrangement has a twofold advantage over a *panchahuteur*: (1) the number of slip-rings is reduced to one-half, (2) the copper loss is reduced by about 33 per cent. If the supply is a two-phase one two commutators will be required, and by connecting these in series, as shown in the figure, an absolutely steady continuous P.D. will be obtained between the mains M_1 and M_2. Lastly, the same arrangement is applicable to a three-phase system, by using Scott's method of coupling the transformer windings so as to pass from three to two phases. (See 1899, Abstract No. 1090.) A. H.



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357. *Synchronising of Alternators.* **M. R. Gardner** and **R. P. Howgrave-Graham.** (Instit. Elect. Engin., Journ. 28. pp. 658–664, August, 1899.)—Abstract of paper read before the Students' Section.

358. *Starting and Regulation of Motors.* **C. F. Guilbert.** (Écl. Électr. 21. pp. 46–54, October 14, 1899.)—Recent Patents (see 1899, Abstract No. 756).—(Pp. 207–215, November 11, 1899) Illustrated description of various alternating current motors. (See 1899, Abstract No. 1577.)

359. *Brush Rocker Details and Bearings.* **E. K. Scott.** (Elect. Rev. 45. pp. 665–667, October 27, 1899.)—Illustrated description of the design of various brush rocker bars and dynamo bearings.

360. *Standardising Carbon Brushes.* **E. K. Scott.** (Elect. Rev. 45. pp. 862–864, November 24, 1899.)

361. *Design of Rotary Converters.* **H. F. Parshall** and **H. M. Hobart.** (Engineering, 68. pp. 389–391, September 29th, and p. 450, October 13th) Single-Phase Rotary Converters.—(Pp. 517–519, October 27th) Six-Phase Rotary Converters.—(Pp. 620–621, November 17th, 1899) Four-Phase Rotary Converters.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

362. *Current Distribution in Alternate-Current Networks.* **C. P. Feldmann** and **J. Herzog.** (Elektrotechn. Ztschr. 20. pp. 780–783, November 9, 1899; read before the 7 Jahresversammlung des Verbandes Deutscher Elektrotechniker in Hanover.)—The principles and methods governing the calculation of current distribution in continuous-current networks are well known. In the present paper the author extends such methods to the case of alternating currents, by the very simple and elegant device of supposing the currents which are drawn off at the various points of the network split up into their idle and load components. Two diagrams are then drawn for the network, in one of which are shown the idle currents, and in the other the load currents. The problem is next solved separately for each of these two cases, the idle and load current distributions being determined by the ordinary methods used in connection with continuous-current networks. Finally, the two solutions are superposed (the superposition of currents being, of course, a *vectorial* one), thus giving the required solution of the problem. A numerical example is worked out by way of illustration. A. H.

363. *Calculation of Sizes of Distributing Mains.* **A. Hecker.** (Deutsche Zeitschr. Elektrotechn. 6. pp. 162–165, October 15, and 173–176, November 1, 1899.)—The author considers the case of a distributor, simple or branched (and fed from one end only), the total fall of potential along which is given. He then supposes that the cross-sections of the various sections of the distributor are varied until the total amount of copper required for the distributor becomes a minimum, and deduces formulæ for the drop of potential along each section of the distributor when the conditions of (1) given total drop and (2) minimum total copper are satisfied. A. H.

364. *Insulation Difficulties due to Capacity of Alternate Current Networks.* **M. Leblanc.** (Écl. Électr. 21. pp. 81–94, October 21, and 172–180, November 4, 1899.)—A long paper, mainly of a mathematical character, in which the difficulties of properly insulating networks liable to disturbances due to resonance effects are fully discussed. The author is opposed to the use of concentric cables as being particularly dangerous in this respect.
A. H.

365. *Current Chart for Two and Three-Phase Lines.* (Amer. Electn. 11. pp. 392–393, August, 1899.)—Two charts, constructed by S. Q. Hayes, are given, based on the following formulæ:—

1. $\text{Volts} \times \text{Amps.} \times 2 \times \text{P.F.} = \text{K. W.} \times 1{,}000.$
2. $\dfrac{\text{K. W.}}{\text{Volts} \times 2 \times \text{P.F.}} = \text{Amps. per Phase} \div 1{,}000$ (two-phase).
3. $\dfrac{\text{K. W.}}{\text{Volts} \times \sqrt{3} \times \text{P.F.}} \times \text{Amps.} \div 1{,}000$ (three-phase).

W. G. R.

366. *Protection of Secondary Circuits from Fire Risks.* **C. T. Hutchinson.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 427–437. Discussion, pp. 437–450. August and September, 1899.)—In this paper the question of protecting secondary circuits from the dangerous consequences of an abnormal potential in these circuits caused, *e.g.*, by the failure of the insulation between the primary and secondary coils of transformers, is very fully discussed. The author strongly advocates grounding the secondary permanently, as the only sure way to prevent the potential above earth of the secondary system rising above the normal potential of the circuit.

In the discussion, **E. Thomson, C. M. Goddard, Steinmetz, Bell, J. I. Ayer, W. Brophy, Puffer, C. W. Rice,** and **Kennelly** spoke in favour of grounding the secondaries, and **Goldsborough** against. It was resolved *inter alia* that the Amer. I. E. E. should officially recommend the National Board of Fire Underwriters to pass a rule permitting or requiring the permanent grounding of one wire of secondary systems, under suitable restrictions. C. K. F.

367. *Distribution of Electricity.* **C. D. Taite.** (Electrician, 43. p. 371. Discussion, p. 372, July 7, 1899. Paper read before the Municipal Electrical Association.)—In alternate-current systems isolated transformers are being replaced by a number of transformers banked in substations to the extent of 200 kilowatts each. Transformers thus connected directly in parallel frequently do not share the load in proportion to their outputs, and are consequently liable to overloading. A demand indicator should be connected in circuit with each. Disconnecting boxes should be employed at frequent intervals. The pillar-boxes of the Southport station are described. The cost of making service connections is very high, amounting to £11 or £12 per consumer. This is analysed, and the possibility of reducing it discussed. The generating expenses of electric lighting stations have almost reached a minimum, and cheapening in future is to be looked for in the reduction of capital and standing charges. A discussion followed. L. B.

368. *Electric Transmission.* **J. Swinburne.** (Instit. Civ. Engin., Proc. 138. pp. 478–481, October, 1899 (Abstract); also Engineer, 87. p. 574.)—The author considers the questions of the copper and insulation used in leads for long distance transmission of energy. Taking the same maximum voltage (10,000) and working at the same current density, the author gives the following comparative table for the power transmitted in the various cases :—

Current.	Output in Kilowatts.		
	Case 1.	Case 2.	Case 3.
Direct	4000	2000	2000
Single Alternating	2824	1412	1412
Double ,,	1650	1650	1170
Triple ,,	5000	2824	2824

Case 1 referring to systems earthed at a middle point ; Case 2 to systems with one conductor earthed ; and Case 3 to systems where the difference between no two conductors exceeds 10,000 volts. W. G. R.

369. *Electrical Transmission and Distribution.* **H. F. Parshall.** (Instit Civ. Engin., Proc. 138. pp. 486–487, October, 1899 (Abstract) ; also Engineer, vol. 87. p. 612.)—An increase in the pressure of overhead lines leads directly to economical transmission, so far as concerns the cost of conductors and the efficiency. For underground cables 20,000 volts may be taken as the present safe limit.

A number of small substations are commercially more economical than the same number of complete generating stations, because they occupy less space, and are free from objectionable vibration and noise. They involve lower efficiency in transformation, higher first cost, and heavier charges for attendance, but a saving is effected both in feeders and distributors, and feeder losses are smaller.

With rotary converters it is advantageous to connect for six-phase transformation instead of three-phase. Early difficulties with the rotary converter have been largely overcome by more careful design both in the converter itself and also in the prime mover, in which the production of a constant angular velocity is most important. E. K. S.

370. *Use of Batteries and Boosters.* **P. Girault.** (Ind. Élect. 8. pp. 213–216, and 368–369, August 25, 1899.)—The author states that every continuous-current central station for the distribution of electric energy should use batteries and boosters, since their use tends to keep the load on the generators constant. Series boosters run at constant speed and, connected to the different feeders, keep the pressures at the centres of distribution equal to that at the station. The generators, being then under constant load, should be simple shunt machines. W. G. R.

371. *Double Current Generators for Power Transmission.* **E. Thomas.** (Electrician, 44. pp. 190–191, December 1, 1899.)—After reviewing the points and opinions which are usually taken into consideration when selecting a system of distribution, the author shows where double-current generators are likely to prove most useful, viz., as intermediaries in stations where both direct-current and alternating-current plant is installed, and also in those stations where the greater part of the load is of one class only. They are also the most economical generators suitable for a long-distance, lightly loaded railway line, the direct-current side feeding the station end of the line and the distant parts being fed from rotary converters in substation supplied from the alternate-current side.

The armature reaction and the number of poles required tend to reduce the efficiency of working, the best results being obtained with large units and a frequency of 25 cycles per second. E. D. P.

372. *Electric Mining Plant.* (Elect. World and Engineer, 34. pp. 445–447, September 23, 1899.)—At Santa Rosalia, Southern California, a copper-smelting works has been equipped with an electrical installation consisting of four engines aggregating 1,500 H.P. and driving three-phase inductor alternators. Condensing water is obtained from the sea, rain being almost unknown. Power is transmitted at 5,200 volts to the copper mines, twelve miles distant, and to Santa Rosalia, where it is transformed down to 380 volts for industrial purposes. For lighting the town it was found necessary to convert to direct current, on account of the irregularities of pressure caused by the starting of induction motors. Details of the machinery are given, with illustrations. A. H. A.

373. *Working Costs of Isolated Electrical Installations.* **P. R. Moses.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 325–347. Discussion, pp. 347–368, June and July, 1899.)—This paper deals with the cost of electricity in typical buildings in New York City, U.S.A., as compared with the cost of supply from central stations. The cost of electricity is defined as the difference between the cost of supplying the other requirements of the building alone and the cost of supplying both these and electricity from private plant. Interest and depreciation are included at 5 per cent. each. Numerous load curves, taken from various types of building, and a mass of data in connection with the detailed costs of operation, are given. A few of the results are summarised below:—

Type of Building.	Total Cost per kw. Hour.	Coal per kw. Hour.	Kind of Load.	Approx. Annual kw. Hours.
Large hotel	0·83d.	3·4 lbs.	Fluctuating	825,000
Small hotel	1·22	8·37	Steady	100,000
Apartments	2·35	7·0	,,	55,000
Large store	1·42	9·25	,,	200,000
Small store	2·05	12·8	,,	50,000
Large office building	2·18	9·4	Fluctuating	158,000
Small office building	2·53	7·25	,,	40,000
Loft building	1·30	8·0	,,	100,000

The average price of electricity supplied from the Edison central stations was 5·3d. per kw. hour during 1898. Full details are given of the methods of obtaining the necessary data and of the installations themselves.

In the discussion **H. W. Leonard** preferred 15 per cent. for interest and depreciation, and pointed out the value of the space occupied by the plant. **A. Williams** remarked that exhaust steam for heating was required in the morning, but not in the evening, when the supply was at a maximum, and gave instances where the station supply was proved to be the cheaper, and where the energy actually generated was far less than had been believed. He also disputed various conclusions of the author, and gave instances of gas-driven plants, of which the cost of working exceeded the central station charges. **C. P. Steinmetz** said that for the greatest economy elevators should be balanced so that the motor overcomes the friction only. In a communication **C. Blizard** supported the use of storage batteries in isolated plants. A. H. A.

374. *Electric Power in Steel Works.* (Amer. Electn. 11. pp. 456–458, October, 1899.)—A description of the electrical plant used at the works of the Illinois Steel Company, Chicago. In addition to the ordinary electric travelling cranes, of which there are several, electricity is the power employed for charging the open-hearth furnaces, shifting tables in the slab mills, and for magnetic lifts and trolleys in the plate mills. Descriptions and illustrations are given of these machines. In the generating station are two Westinghouse machines, a 400 kw. and a 300 kw. supplying direct current at 250 volts pressure. Six Thomson-Houston machines are provided for the arc-lighting and are driven in pairs by 100 H.P. Westinghouse motors supplied from the main generators. There is also a 60 kw. alternate-current machine for the incandescent lighting. It is estimated that a saving of 50 per cent. in the cost of power is effected by the substitution of electric power for the steam power formerly used. E. D. P.

375. *Mt. Whitney, Cal., Transmission Plant.* **D. H. Fry.** (Elect. World and Engineer, 34. pp. 648–649, October 28, 1899.)—An illustrated description

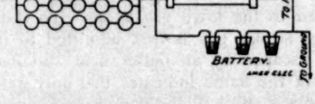
of these works is given, dealing more particularly with the hydraulic power supply.

The Kaweah River is naturally adapted for the work required ; a natural granite dam forms the headworks, and the lowest mark the river has yet reached will supply a flow far in excess of the maximum required at the works.

The pool is tapped by a tunnel through rock, and from this starts a wooden flume, 30,000 feet long, with a fall of 1 in 200, 3 feet wide, and 2 feet deep. The pipe line, 3,300 feet long, has a fall of 1,325 feet, is 20 inches diameter at the penstock, reducing gradually to 19 inches at the receiving end, is made of lap-welded steel, and instead of the usual bolted flange joints, has one end of each pipe length belted and a riveted joint made. Details are given of the method of erecting and the principles embodied in the design of the hydraulic plant.

The generating units consist of three three-phase, 450 kw., 440 volts Westinghouse alternators ; the water motors being of the Pelton type of 700 H.P. each. The exciters are driven by belts from the main machines, the author having found that in works working with high heads of water the small wheels necessary to drive exciters separately are not to be relied on. The transmission-line pressure is 17,300 volts. Five substations are used, and from each the energy is distributed at 2,000 volts pressure. An apparatus invented by Lacey is used on some of the private circuits. It consists of an electromagnetic current interrupter which, when placed in series with the main circuit and adjusted, causes the lights on that circuit to flicker should the number allowed be exceeded. When the excess of current is cut off then the interrupter is steadied by its control, which can be adjusted for any current. It is more convenient and sensitive than fuses, and is useful for those customers who pay on the flat-rate system. E. D. P.

376. *Gas-Driven Traction Power Station.* (Amer. Electn. 11. pp. 206–208, 1899.)—This is an example of the successful regulation of gas-engine driven dynamos for the extreme load changes on a small electric road. The trunk lines of the Long Island Railroad Company do not run close along the shore. The Port Jefferson branch line follows an elevated tableland, and the nearest point is about two miles from the village of Huntington. The Railroad Company bought up the local horse railway and worked it electrically as a feeder to the main line. This single-track line, about three miles in length, runs from the shore to the village of Huntington, and rises 165 feet to the station with gradients up to 4½ per cent., or 1 in 22.



The power plant at the shore end consists of two Westinghouse three-cylinder vertical gas engines, each of 50 nominal H.P., supplied from the local gas company. The regulation of speed is by varying the amount of the charge, instead of the hit-or-miss method of governing. Current for the electric igniters is taken from the 500-volt dynamos, and passed through 20 incandescent lamps connected in four groups of five lamps each in series (see fig.) and thence to the spark coil and igniters. The high voltage tends to keep up an arc across the igniter contacts and causes "back fire" in the mixing chambers when the admission ports are opened. To overcome this there is a shunt around the spark coil and igniters, consisting of a battery of three glass tumblers with lead strips bent over and dipping into dilute sulphuric acid. These take the current when the igniter circuits are open, reducing the voltage across the igniters to about 7 volts, and absorb a charge which is given out again to the igniters when their circuits are closed. When starting the engines the igniters are supplied by a battery of 12 Edison-Lalande primary cells.

Each gas engine is belted to a 37½ kw. Westinghouse four-pole 550-volt dynamo. There is a storage battery of 265 chloride accumulators, having a maximum discharge rate of 44 amperes for short periods, and worked directly in parallel with the dynamos without booster or end cell switch. The compound winding reduces the voltage of the dynamo as the load rises, so that the battery takes the greater part of the load fluctuations.

The line has been running since June 20, 1898, with one car in winter and three open cars in summer, and has carried 5,000 passengers in a single day. The ordinary car mileage is two hundred miles per day, and the gas consumption 46 cubic feet per car mile, the total working expenses with gas at 90 cents per 1,000 cubic feet, and including the wages of motor men and conductors, being 13 [6½d.] cents per car mile. W. R.

377. *King's Lynn Electricity Supply Works.* (Electrician, 43. pp. 722–729, September 15, 1899.)—In this public supply station producer gas is generated and utilised to drive Otto cycle gas engines belted to continuous-current dynamos which supply, through a regulating battery of accumulators and a balancing transformer, current at 2×200 volts to a three-wire distributing network.

A 9 H.P. vertical boiler generates steam at 30 lbs. per square inch for four gas generators. The steam is superheated in pipes by the hot gas between the producers and coolers. Each generator makes, from Welsh anthracite, 13,000 cubic feet of gas per hour at a pressure of 1·5 inch of water, and having a calorific value of 145 British thermal units per cubic foot. The gas, cooled in vertical cast-iron pipes, passes through a hydraulic box and coke scrubber provided with a continuous supply of water, and next over trays of sawdust and chips to gasholders. The gas engines, of Fielding and Platt, work on the Otto cyc'e. Each engine has duplicate ignition tubes, one of which is connected to the town gas mains. To start the engine with the piston on working stroke, gas is first admitted to the combustion space, and the mixture escapes by an outlet near the flame for ignition tube. When the colour of the flame indicates that only gas is escaping the outlet is closed, the supply is shut off, and compressed air admitted from a small reservoir, into which it is pumped by the engine. The compressed mixture moves the piston forward, and then explosion takes place and the engine is started.

Each engine is of 65 B.H.P. and drives a 40 kw. dynamo. At full load the consumption is not to exceed 85 cubic feet of gas per hour per I.H.P., and for this not more than 1 lb. of anthracite coal is to be used per hour in the producers. The speed is regulated on the hit-and-miss plan, and the fluctuation of volts is not greater than 1 per cent. at full load and 2 per cent. at quarter load, and the speed must not increase 5 per cent. when half of full load is thrown off. The dynamos are two-pole, overtype shunt machines, each having 160 commutator segments, and at 150 revolutions per minute can develop 88 amperes at 450 volts, and when charging batteries 80 amperes at 540 volts.

The battery, 225 cells of the chloride R 17-plate type, has capacity of 400 ampere hours for 10-hour discharge and 320 ampere hours for 4-hour discharge down to 1·85 volts per cell, and can stand 150 amperes for short periods. The pressure is regulated by switching cells in and out; also by iron resistance in series with the feeders. The middle wire is directly earthed at the station. Balancing transformers are in a substation in the centre of the district, about a quarter of a mile from the generating station. The two balancers are two polar, both armatures wound on the same drum with only one field magnet. At 1,250 revolutions per minute a balancing current of 50 amperes is generated in either armature. The feeders are branched, so that each serves two feeding-points.

A special reversing junction-box is provided at every fifty yards for service connections from the triple-concentric distributors. The street lighting is by both incandescent and arc lamps. The charge for light is 5½d. per B.T.U., and for power 3d. per unit. W. R.

378. *Perth* (*W.A.*) *Electricity Works.* (Elect. Rev. 45. pp. 927–928, December 8, 1899.)—Three-wire direct-current system with accumulators is used, and the rapid progress of electric lighting in the town is dealt with. An interesting account is given of the rapid change-over of the whole system, both on the distributing network and in the station, from 220 volts maximum to 440 volts maximum. E. D. P.

379. *Albion Power Company's Water Power Transmission Plant.* **O. E. Dunlap.** (Elect. Rev. 45. pp. 928–930, December 8, 1899.)—Description of the works of the Albion Power Company. The generating station at Waterport is 6½ miles from Albion. A dam 200 feet long and 12 feet high is built across the Old Orchard Creek, forming a large reservoir, by setting the river back for three-quarters of a mile. The available fall is 18 feet. The flume is built into the earth bank, and consists of a steel framework filled in with concrete to a thickness of about 2 feet. Two McCormack wheels are installed, 250 H.P. and 175 H.P., each driving a three-phase, Stanley inductor type, alternator. The machines are designed to run in parallel and feed the transmission line at a pressure of 6,600 volts. The exciters are driven by bells from the main generators. The overhead line consists of three seven-stranded aluminium conductors, supported on triple-petticoated glass insulators, the poles being 30 feet high and 100 feet apart.

The pressure is transformed down to 1,100 volts at the Albany substation, which contains a 75 H.P. inductor alternator of similar type to those at Waterport. This is provided with an exciter and also a three-phase starting motor of 5 H.P. to bring it up to speed, when it is run off the 1,100-volt mains as a motor to drive a Brush arc machine for street lighting. At this substation there is also installed a steam-driven plant as a reserve, having a capacity equal to that of the works at Waterport. The town circuits are divided into three sets, each being fed by one leg of the three-phase system, transformed to 110 volts. A three-phase line is also run round the outskirts of the town to provide light and power. E. D. P.

380. *Blackpool Trams.* (Elect. Rev. 45. pp. 359–368, September 1, 1899.)—Disfigurement of the streets is avoided by using short bracket arms and long

(20-foot) trolley poles with special springs. Two Parson's turbines supply 400 H.P. at 500 volts, each turbine driving two dynamos at 250 volts coupled in series. Quin's maximum and minimum cut-outs disconnect each section of wire (1) in case of a short circuit, and (2) in case a trolley wire is broken, by means of shunt and series coils acting in opposition. Askham and Wilsons made the points and crossings, Lowdon and Co. the 152 poles of mild steel, which are butt-welded, 28 feet long, 8 inches outside diameter at the foot, 5 inches at the point, and $\frac{7}{16}$ inch thick. They are slipped into a cast iron plinth (by McFarlane) and traversed by the cross-arm tube, 2 inches outside diameter and $\frac{1}{4}$ inch thick, which supports a 000 copper wire having 28 tons per square inch tensile strength. The cars, by Milne and Co., carry 86 passengers. M. O'G.

381. *Electric Railway Systems of Quebec.* (Street Rly. Journ. 15. pp. 495–502, August, 1899.)—The city of Quebec is so hilly that it was found impossible for the electric cars to ascend some of the streets. To overcome this difficulty a trestle was adopted, which ascends the first portion of the hill obliquely with a grade of 7 per cent. On reaching a certain point, where the trestle meets one of the cross-roads, a curve was located on a level section on the trestle, after which the grade is 11 per cent. for 800 feet, then 4 per cent. till the Upper Town is finally reached.

Owing to the heavy snowfalls in this region it is necessary to employ sweepers, levelling ploughs, and box sleighs. The total equipment for the disposal of snow consists of six sweepers, each equipped with two 30 H.P. traction motors, and another motor of the same type placed in the cab for revolving the brooms, several horse-drawn levellers, and numerous box sleighs.

The brakes employed on the cars consist of ordinary brake shoes made of specially soft cast iron, with the flanges perforated to permit the mud to percolate freely, and provided with a brake leverage of 10 to 1. Under these conditions skidding is very uncommon. The wheels are 33 inches in diameter. The brake shoes have an average life of three months. The average number of wheels worn flat is only 14 per cent. of the total number of worn-out wheels, and these are mostly due to a slippery track in winter. A test was made recently to ascertain the current consumption in ascending the heavier grade, one of 14·15 per cent., 90 feet long, with a 40-foot radius curve on the summit, half of which is on the hill. Under the most favourable summer conditions the maximum current drawn by the two motors during the ascent until the curve was reached was 65 amperes at 520 volts; then after being switched off on reaching the curve and again thrown on, the maximum reading was 130 amperes, still at 520 volts, for it is customary to throw the power completely off the moment the car enters the curve, and as the car commences to lose momentum the power is thrown on again. The average speed of the car was 4·5 miles per hour, and the estimated weight 9 tons. Under average winter conditions the current consumption rises to nearly 100 amperes on the grade and to about 195 amperes on rounding the curve.

In descending all heavy grades the motor-men are obliged to come to a standstill at the top to ascertain if the brakes are in good working order, after which the speed downhill must not exceed four miles per hour, so that a stop may be made if necessary on the hill. As all the excessively steep grades are short, the time lost in going slow is very small.

The average power consumed in summer, as obtained by the integrating wattmeter in the station, is 8·3 kw. per car per hour, the average for the whole year being about 9·5 kw. per car per hour. The average mileage per car per day is 106.

The trolley wheel is of soft brass, 4¼ inches in diameter, and as it is carefully greased every day it seldom leaves the trolley.

Its average life is 10,000 miles, or about 95 days. Commutators run 25,000 miles before being sent to the lathe. The greatest wear on the commutator has been a decrease of $\frac{3}{16}$ inch in the diameter ; the average has been ⅛ inch. The brushes used are of the Le Valley Vitæ manufacture. L. J. S.

382. *Electric Tramway in Batavia.* **H. Lippegaus.** (Elektrotechn. Ztschr. 20. pp. 742–747, October 26, 1899.)—A description of the first electric tramway to be established in the Dutch possessions of the Malay Archipelago.

In order to guard against injury to this power station from the slight earthquake shocks which are prevalent, the foundations are strengthened throughout by a framework of wrought-iron girders.

The boilers, three in number, are of the double drum type, each 7 feet diameter, the upper drum 19¾ feet and the lower drum 23 feet long. With a heating surface of 1,070 square feet and Australian coal, the normal evaporating capacity is 3,300 lbs. per hour. The furnaces are so arranged that petroleum waste may be burnt instead of coal.

The three engines are of the McIntosh and Seymour horizontal tandem compound type, each 150 H.P. at 235 revolutions per minute. The dynamos are six-pole machines by the Union Elektricitäts-Gesellschaft, Berlin, economiser by Green, Worthington pumps, &c.

These lines (gauge 1.18 metres, and of lengths 5 miles, 3 miles, ¾ mile) are laid to one side of the public roads, the rails resting on sleepers of Dyatti wood, an Indian oak which resists the attacks of the white ant. There are eight feeders. The rails are used as return, being copper bonds 0·16 square inch area.

[A description, more liberally illustrated, appears in the Electrical Engineer for November 17th and 24th and December 8, 1899.] E. K. S.

383. *Coblenz Electric Tramway Station.* (Elektrotechn. Ztschr. 20. pp. 635–637, September 7, 1899.)—A station laid down by the Union Elektricitäts-Gesellschaft, of Berlin. The generating plant consists of (*a*) two direct-current 150 kw. six-pole dynamos, giving current to the trolley line direct at 500 volts, and (*b*) two three-phase alternators generating current at 2,080 volts for the substations. All the machines are direct coupled and run at 150 revolutions per minute, there being three engines, one with a dynamo, one with an alternator, and the third having both a dynamo and alternator coupled at either end of the crank shaft. There are two sets of accumulators—one a buffer battery consisting of 275 cells connected to the trolley wires, and the other having 65 cells, being in the exciting circuit of the alternators. Three motor transformers are provided, (*a*) to enables the alternator to deliver current to the station end of the lines, and (*b*) for charging the exciting cells or exciting direct from the direct-current dynamos. The whole plant is well and simply arranged. E. K. S.

384. *Reichenberger Tramway.* **M. U. Schoop.** (Zeitschr. Elektrotechn. Wien. 17. pp. 467–473, September 10, 1899.)—A description of a tramway in which great use is made of buffer batteries. The accumulator cells are by G. Hagen, and curves are given in the article showing the advantages of the method of working in getting over the peaks of the load curves and for

regulation. Particulars of two tests of the generating plant are given as follows :—

Test of two Lancashire boilers; steam pressure, 8 atmospheres; two horizontal compound condensing engines (Breitfeld, Danek and Co.), and two eight-pole, belt-driven dynamos (Schukert and Co.).

		Normal load.	Overload.
Duration of test in hours		7	8
Total water evaporated	kg.	8,488	12,420
Used in boiler-house	kg.	114	114
Used in engine-house	kg.	95	80
Balance	kg.	8,279	12,226
Indicated H.P. of engine		152·8	192·2
Steam used per indicated H.P. hour	kg.	7·74	7·95
Electrical H.P. on dynamo pulley		128·35	166·4
Brake H.P. of engine		132·2	171·4
Efficiency of dynamos		90%	91%
Loss in belt drive		3%	3%
Efficiency of engine		86·5%	89·2%
Revolutions per minute		126	125
Heating surface of boilers		80 sq. metres.	
Grate area of boilers		1·65 sq. metres.	
Water evaporated per square metre of heating surface per hour	kg.	15·2	19·4
Coal burnt per hour	kg.	162	227
Coal used per square metre of grate area per hour	kg.	98·3	137·8

E. K. S.

385. *Accumulator Traction* (*Louvres to Vincennes, Paris*). **A. Monmerqué.** (Électricien, 18. pp. 104–108, August 12, 1899. Extract from the Revue Générale des Chemins de fer.)—Gradients and details of this scheme, which is already commenced, are given. Power up to 2,000 kw. is provided for, the present installation of 1,600 kw. being divided into five sets, three direct coupled dynamos with horizontal engines at 70 revolutions per minute and two dynamos coupled to a Laval turbine—the latter being used on account of the great rapidity with which it can be started up. Circulating and air pumps for condensers are electrically driven and take 6 per cent. of the output. The voltage of the direct coupled sets can be varied by the field alone from 540 to 580 volts. The armatures are gramme rings rotating outside an eight-pole field —the periphery constitutes the commutator. The Laval turbine drives, through a bronze gear-wheel and pinion, a dynamo which has two armatures coupled in series. The set yields 200 kw. The gear is in a grease-tight wrought-iron case. The boosters for accumulator charging, &c., are 40 kw. series dynamos driven by shunt motors taking current from the main board; they are four in number, one on the positive and one on the negative pole of the two pairs of feeders. Eighty-five cars having fifty-two seats are proposed. The motor cars weigh 18 tonnes, trailers, 8·3 tonnes. The accumulators are specially ventilated and weigh from 4,600 to 4,700 kgrs. The cells will be charged in fifteen minutes, and their energy efficiency will not be less than 70 per cent.; their specific gravity capacity is to be 6·2 watt hours per kgr. of plates, *i.e.*, 3·9 watt hours per kgr. of cell. In exceptional circumstances 13·5 watt hours may be required on the Louvre-Vincennes route. M. O'G.

386. *Electric Transmission between Bozen, Meran, and Nachbarote.* **O. v. Miller.** (Elektrotechn. Ztschr. 20. pp. 615–619, August 31, 1899.)—Detailed description of an important three-phase transmission plant laid down by Ganz & Co. The power station is situated 5 kilometres from the town of Meran (Austrian Tyrol), and is equipped with six turbines each of 1,000 H.P., working under a head of water of about 66 metres. The three-phase alternators are direct driven at 320 revolutions per minute, and each is fitted with a four-pole exciter. Four of the alternators generate current at 3,600 volts, and two are arranged to give either 3,600 volts or 10,000 volts, the latter pressure being required for the long-distance line between Meran and Bozen. The switchboard is so arranged that two of the alternators can be connected on to the 3,600 volt 'bus bars for the electric lighting of Meran, or on to 3,600 volt special 'bus bars for power to a carbide factory.

The disposition and lengths of lines and the amount of energy required for lighting and power is as follows :—

Three-phase line at 3,600 volts for Meran and Nachbarote.
Three-phase line at 10,000 volts for Bozen and Zwischenork.
Three-phase line at 3,600 volts for the electrochemical factory.

Area of each of the three conductors to Meran 6·5 square mm., and to Bozen 6 square mm.

Total length of main transmission line, 39 kilometres.
Total length of overhead distributing cables, 30·4 kilometres.
Total length of underground cables, 88·2 kilometres.
Street lighting, 83 arcs, 770 incandescents.
Private lighting, 21 arcs, 24,500 incandescents.
Motors, 45 H.P.
Electrochemical factory, 2,000 H.P.

A very clear diagram of connections of the power-house main switchboard is given, and the plan and elevation of the station indicate the ample space which is provided behind the board for the extra high tension switches and 'bus bars, Siemens-Halske horn lightning arresters, &c.

Three cross-sections are given of the transformer substation at Gries, near Bozen, where the pressure is reduced from 10,000 to 3,000 volts, and six cross-sections of a street switch pillar.

The charge for light has been fixed at 7 florins (11s.) per 16 c.p. lamp per annum, and for motors at 50 florins (£4) per H.P. per annum.

E. K. S.

387. *Cost of Electric Traction.* **G. C. Cuningham.** (Instit. Civ. Engin., Proc. 138. pp. 485–486, October, 1899 (Abstract); also Engineer, vol. 87, p. 611.)—The cost of horse traction may be taken as varying from 3½d. per car mile in towns with easy gradients, to 5d. in hilly towns. In overhead electric traction, with economical engines and boilers, the cost of wages, fuel, water, oil, &c., in the power house, together with maintenance and repairs of the machinery, should be less than ½d. per car mile in level towns and but little more than ½d. in towns with steep gradients. On the Montreal Electric Street Railway, for example, with coal at 9s. per ton, the cost of producing current is a little under ¼d. per kilowatt hour, and the cost per car mile less than ½d. in the open months of the year. The coal consumption is 3·48 lbs. per kilowatt hour, or 2·60 lbs. per E.H.P. hour during several months; while the average for a whole year is only 2·75 lbs. per E.H.P. hour.

The *whole cost* of working a large electric tramway should be well under 5d. per car mile, but this result can only be obtained where the cost of the current at the generating station is cut down to a minimum by the use of engines and boilers which do their work with a low consumption of fuel. It is, in fact, upon the construction and economical working of the machinery in the power house that commercial success depends. E. K. S.

388. *Comparative Costs of Cable Electric and Horse Traction in New York.* (Street Rly. Journ. 15. pp. 579–580, September, 1899.)—In Abstract No. 524 (1899) was given the comparative results of the expenses and receipts of the cable lines, the electric (underground conduit) lines and the horse railway lines of the Metropolitan Street Railway Company of New York City. The present article gives in comparison with these figures those of the corresponding financial year just ended. The comparison is the more valuable, inasmuch as the track mileage of the system is the same this year as last, the results not being complicated by the purchase of new lines or the building of extensions.

In the last year the Company ran its cars over the same track nearly 42 million miles as against 35 million miles in the previous year, the new cars being, moreover, nearly double the capacity of the old. The passenger receipts jumped nearly 25 per cent. as a consequence, while the receipts per car mile were actually increased from 29·7 cents to 30·7 cents, or 3 per cent. The traffic of the cable lines fell off about 10 per cent., and of the horse lines about 30 per cent., while the electric lines carried three times as many passengers in 1899 as in 1898, and their receipts per car mile increased from 26·99 cents to 31·23 cents.

The percentage of operating expenses to passenger receipts of the three motive powers compare as follows:—

	1898. Per cent.	1899. Per cent.
Cable	47·8	50·8
Electric	37·9	38·3
Horse	65·3	69·8
Total	53·3	49·4

A general financial statement in tabular form accompanies this article, from which the following has been obtained:—

	1898.	1899.
Receipts from all sources	$11,076,021	13,525,524
All operating expenses	$5,620,484	6,408,711
Earnings from operation	$5,455,537	7,116,813
Per cent. operating expenses to total receipts	50·7	47·4
Fixed charges	$3,609,966	4,477,757
Dividends paid	$1,500,000	2,471,675
Surplus over dividends	$345,570	167,381

L. J. S.

389. *Railway Power Distribution over Large Areas.* **A. H. Armstrong.** (Street Rly. Rev. 9. pp. 579–580, September 15, 1899.)—A paper read before the Street Railway Association at New York, and descriptive of the power supply to the various electric street railways operating in and around Buffalo.

For such a heavy load and extended area *a single generating station* was not looked upon as desirable on account of the great expense of the feeders; whilst the employment of boosters as a permanent means of replacing feeder copper where heavy overloads may be of long duration is also very objectionable. Overloads of short duration, especially if they are local, can very well be taken care of by boosters, but the cost of the energy lost in boosting long daily overloads would be very considerable.

Having *two separate generating stations* reduces the feeder copper, but the first cost and cost of operating two stations is greater than that of operating a single station of the combined capacity of the two.

The third method by rotatory converter substations was therefore adopted because it permits substations to be located wherever there is the greatest demand for power. The small section high pressure transmission line can be carried underground to any locality, and as the station itself requires no boilers or engines it may be located in busy neighbourhoods. The largest congestion of cars, and hence the largest demand for power, exists in the business districts, and it is owing to the possibility of placing machines close to the powers of greatest demand that makes the substation system especially adapted to the operation of large street railway systems.

The labour charge is higher, but it is pointed out in the paper that the number of attendants need be only two for a substation of a capacity of say 1,200 kilowatts. It is now proposed to shut down the present power house and keep it as a reserve; the whole of the system of the International Traction Company in Buffalo, Niagara Falls, Tonawanda, and Lockport being then driven from rotary converters fed by the Niagara Falls power. There are to be six substations as under :—

Substation.	Maximum Output.	Converter Installed.	Ultimate Capacity.
No. 1	760 kw.	800 kw.	1,200 kw.
„ 2	870 „	800 „	1,200 „
„ 3	1,230 „	1,200 „	1,600 „
„ 4	870 „	800 „	1,200 „
„ 5	890 „	800 „	1,200 „
„ 6	1,600 „	1,600 „	1,600 „
	6,220 kw.	6,000 kw.	8,000 kw.

The maximum output is for the winter months when car-heaters are in constant use.

The step-down transformers in the various substations take three-phase current at 10,500 volts, and reduce it down to 375 volts, which corresponds to 600 volts direct current on the commutator of the rotatory converter. The transformers are connected in delta, so that the disabling of one transformer of a set does not throw the converter out of service. Direct current-blower sets are provided in duplicate, and feed into a common air chamber from which individual transformers, &c., draw their supply. Artificial reactance is introduced between the transformers and converters to enable the latter to regulate with varying loads. A special starting set consisting of an induction motor coupled to a dynamo has been installed in two of the substations, which permits the starting of the converters from the direct current end, and ensures bringing them into synchronism in a minimum of time with the right polarity. The converters in adjacent substations can then be started from the direct current feeder system. E. K. S.

390. *Buffer Batteries for Electric Traction.* **L. Gebhard.** (Zeitschr. Elektrotechn., Wien. 17. pp. 418–423, July 30, and 429–433, August 6, 1899.)—This is a paper read before the Elektrotechnischer Verein, Wien. In designing traction stations it has been usual to make the dynamos large enough to take the maximum loads allowing a suitable stand-by, and to use a battery merely to regulate the voltage and supply the light load when the plant is shut down. It is then an extra capital charge, and is therefore made as small as possible. The true use of the battery is rather to allow the plant installed to be reduced till it is just sufficient to take the average load, relying on the battery to supply the additional demand and to act as the necessary stand-by, thus keeping the load factor at 100 per cent., and effecting a large saving both in capital outlay and in generating expenses. A specimen traction-load curve taken from the Remscheidt station is given. In large stations the advantage of a buffer battery is not so marked owing to the more even load curve demanded. In Hamburg, for instance, with an average load of 2,000 amperes, the maximum momentary output reaches only 2,400, which could easily be obtained as an overload from a 2,000 ampere plant. But even here the avoidance of sudden shocks on the generators is very advantageous, and a battery with a capacity of 1,600 amperes for one hour has been installed. In Leipzig, in spite of the large output, a saving of 30 per cent. was effected in the generating expenses by the installation of a battery of similar capacity. A graphic method is described for determining the periodic variations in the load curve, and thence the average load, from the profile of the line and the schedule of the service of cars. To determine the H.P. required by a car at any moment the following formula is given :—

$$\text{H.P.} = \frac{6wv(1{\cdot}25\mu + S)}{E}$$

Where μ, S and E are the traction coefficient, the gradient and the efficiency of the motors and gear, all expressed as percentages, w the weight of the car in tons, and v the speed in miles per hour. The coefficient 1·25 is introduced to cover variations in the condition of the track, losses in the starting and regulating resistances, &c. The traction coefficient μ may usually be taken as 1·2 per cent.

From this graphic solution the following rule is demonstrated : The average power required for all the cars on a given track can be found by dividing the work required to propel one car for the double journey by the scheduled time in seconds between the cars. And this is the maximum output required from the dynamos if an efficient buffer battery is employed. It should be large enough to supply this average load itself for one hour, and its internal resistance, which depends largely on its capacity, should be small enough to keep the voltage from falling too low on a momentary rush of current. The drop of voltage owing to the battery resistance should not be more than 5 per cent. when giving an extra output equal to the average output of the plant. These conditions determine the size of battery required.

For all gradients less in magnitude than the traction coefficient the power used in going up is saved in the descent on the return journey. Hence the calculation of the average power required can be simplified without reducing its accuracy by neglecting all such gradients. The loss of power in the starting and regulating resistances is not taken into account in the above formula. But such losses are amply covered by the 25 per cent. allowance in the traction coefficient, particularly if the stopping-places are sufficiently definite to avoid frequent unnecessary use of the brake.

Details are given (p. 429) of the capital and working expenses estimated for a four-mile tramway between Haspe and Gevelsberg, in Westphalia, showing the great economy attained by the use of a large battery. L. B.

391. *Stationary Accumulators for Traction Work.* **G. Brandt.** (Elektrotechn. Ztschr. **20.** pp. 730–732, October 19, 1899.)—In order to arrive at some reliable experimental data regarding the action of accumulators as regulating devices in traction plants, the author carried out a number of tests for Siemens and Halske. In considering the action of a secondary battery the author introduces the term *characteristic resistance*, which he defines as the ratio of the difference between the E.M.F. and P.D. to the current (the E.M.F. considered being the *steady* E.M.F. which the battery reaches some time after breaking the circuit, and not the instantaneous E.M.F. immediately after the break). This quantity is variable, and it is a matter of great importance to find what factors determine its value. The author's experiments show that the characteristic resistance of a battery is independent of the current, but that it depends on the time during which that current has been allowed to flow, and that the effect of a momentary preceding charge is almost entirely wiped out during the first minute of discharge. The main benefit resulting from the employment of a suitably chosen battery is the saving of fuel consequent on the fact that the engines and dynamos are kept working at their point of maximun efficiency, the fluctuations of load being taken by the battery. The author's experiments lead him to the conclusion that the best mean E.M.F. of the battery depends solely on the type of battery used, and not on the particular conditions of working. In the case of the batteries tested by the author, the best regulating effect was obtained by making the mean E.M.F. of each cell 2·07 volts. From this the required number of cells may be at once determined. A. H.

392. *Energy-Economy in Electric Traction.* **M. Bricard.** (Écl. Électr. **20.** pp. 5–10, July 8, 1899.)—The author considers the waste of energy in braking in a manner similar to that given in Abstract No. 346 (1898). High accelerations should be used.

With electric vehicles two cases arise: (1) where the tractive effort is limited by adhesion (as on rails), (2) where the adhesion is always in excess (as on roads). The author discusses these in detail and concludes that, from the point of view of energy consumed, the tractive effort should be a maximum and the acceleration constant (*i.e.*, constant current, obtained by starting with a large resistance in series and gradually cutting it out as the speed and back E.M.F. rise), but considerations of plant efficiency lead largely to the use of constant (full) voltage. E. H. C.-H.

393. *Combined Single-Phase Alternating and Continuous Current System of Working Electric Railways.* **F. Eichberg.** (Zeitschr. Elektrotechn., Wien. **17.** pp. 318–327, June 14, 1899.)—Single-phase alternating current is picked up from the trolley line and led to a single-phase motor on the car. The car also carries a continuous current motor and a set of accumulators which can be brought into use at starting up, &c.

The paper contains particulars of tests on two trains fitted in this way, the first on a line having a maximum and mean gradient of 20 and 1·3 per cent. respectively, and the second on a line having gradients 5 and 2 per cent. respectively. Diagrams are given showing how the alternating motor and the continuous current motor may be comprised in one single machine. E. K. S.

394. *Electric Traction Problems.* **J. Fekl.** (Zeitschr. Elektrotechn., Wien. 17. pp. 435–440, August 13, and p. 464, September 3, 1899.) — The author shows how, by using the mechanical characteristic of the motor, to calculate the current taken by the motors for a given load and gradient, the speed of the car, the ampere hours per motor and car mile respectively, the mean total current and power, and the mean drop along the line. A. H.

395. *Multiple Unit System for Electric Railways.* **F. J. Sprague.** (Amer. Instit. Elect Engin., Trans. 16. pp. 211–249. Discussion, pp. 249–263, 1899.)—A paper descriptive of the multiple unit system of electric traction (see 1898, No. 344) as applied to the South Side Elevated Railway of Chicago. Each unit or coach of the train is equipped with its own motors and controllers, the latter being actuated by means of small pilot motors which are in turn controlled by the driver in the leading coach.

Some of the advantages of the arrangement are :—

The motor equipment is directly proportional to the number of car units.

Each car being lighted, heated, and braked independently it has independent movement in yards, car houses, or on the tracks.

Cars can be added to or taken from a train in about a third of the time that is possible with a locomotive system.

The fullest use can be made of sidings and tracks for storage and inspection.

The hammering of rail joints, &c., is diminished because of the less weight per driving wheel.

Increasing the number of motors on the train gives more room for increase of dimensions of essential working parts, such as bearings, gears, and commutators of any one motor ; also greater space for the application of brakes—electric and mechanical.

When the total motor capacity, say 600 H.P., is concentrated on one car of a six-car train, there is not the same ratio of weight on the drivers, and consequently a much smaller effective pull than with many smaller motors distributed over all the six cars of the train.

The discussion took the form of a series of questions, to each of which the author very ably replied. In replying to the suggestion that the controlling mechanism was intricate, the author stated that experience showed very little liability of the small pilot motors to get out of order. He pointed out that the cost of plant per H.P. in the generating station is about ten times what it is for the train equipment. It is therefore economical to expend money on the motors, controllers, &c., if by so doing the total H.P. of the generating plant can be reduced.

In referring to the chloride accumulator battery which has been installed on the South Side Elevated Railway, the author said he was an advocate of the storage battery for regulation and taking the peak loads, if it was put in under proper guarantees. (See also 1898, Abstract No. 344, and 1899, No. 1810.) E. K. S.

396. *Surface Contact Traction Systems.* **G. Claude.** (Ind. Élect. 8. pp. 338–342, August 10, 1899.)—The author discusses the underground conduits and surface contact systems. The following systems are criticised : Ayrton and Perry (1883), Pollak (1887), Lineff (1888), Diatto (1894), Thompson and Walker (1898). These systems are all based on that suggested by Ayrton and Perry in 1883, in which a powerful electromagnet is fixed on each car, and permanently excited from a battery of accumulators. Each section is provided with a stationary magnetic device which, when the car is passing, is attracted by the electromagnet and causes contact to be made with the supply cable. The following systems are also discussed: Claret Vuillenmier, Hopkinson (1882), Wynne (1887), "The Safety Third Rail System," and Potter (1896). L. J. S.

397. *Effect of Temperature on Pull of Trolley Wires.* **M. Eisig.** (Elektrotechn. Ztschr. 20. pp. 653–655, September 14, 1899.)—A formula is given by which the differences of pull on trolley wires due to varying temperatures may be calculated. Assuming the usual practice of a span of 40 metres, area of trolley wire 50 square mm. (equal to 0·316 inch diameter), and a working tension of, say, 400 kilogrammes, the extra pull per degree Centigrade is about as follows:—

From	0° to—10°	Centigrade	8	kilogrammes.
„	—10° to—20°	„	9	„

From	0 to+ 8°	Centigrade	7	kilogrammes.
„	+ 8 to+12°	„	6	„
„	+12 to+20°	„	5	„
„	+20 to+26°	„	4	„
„	+26 to+30°	„	3	„

Twelve kilogrammes per square mm., or a total of 600 kilogrammes for a 50 square mm. wire, is within the safe elastic limit. E. K. S.

398. *Bede Contact System.* **A. Witz.** (Écl. Électr. 21. pp. 201–207, November 11, 1899.)—At present, 82 per cent. of the existing electric tramways are on the overhead system, 7 per cent. on underground conduit, and 11 per cent. on accumulator systems. The Bede system consists essentially of a plough travelling in a slot outside one rail and mechanically pressing horizontally outwards contact pins which pass through rubber glands, and which when pushed back make direct contact with a bared portion of the feeder cable. Details of construction are given. Since the beginning of 1899, 405 metres of the Brussels Tramways Co.'s lines have been working satisfactorily on this system in all kinds of weather. E. H. C.-H.

399. *Electromagnetic Brakes.* **M. Schiemann.** (Elektrotechn. Ztschr. 20. pp. 535–539. Discussion, p. 539, July 27, 1899. Paper read before the Elektrotechnischen Vereins, Berlin, May 30, 1899.)—The conditions to be fulfilled by a good brake for electric cars are enumerated. Rim and axle brakes are useful until the wheels slip on the rails, when some form of rail brake must be resorted to. Electric braking by short circuiting the motors is undesirable, as the kinetic energy of the car is spent in heating the motor. This may be avoided by using a magnetic brake consisting of an iron disc keyed on the axle and acted on by a crown of electromagnets on one side. Braking takes place owing to the eddy currents in the disc and by friction of the disc on the pole faces as the attraction increases. The electromagnets are excited either from the car motor or from the line. A hand brake must be employed to bring the car finally to rest. For more powerful braking than can be applied through the adhesion of the wheels, a magnetic rail brake is described, consisting of a bar suspended longitudinally between the wheels and a few inches above the rail. This bar carries a brake shoe at

each end, and a number of pole shoes along its length, which when excited are attracted on to the rail, thus forcing the brake shoe under the front of the trailing wheel, effectually bringing the car to rest on emergency or allowing it to run at reduced speeds as required. Experiments with this form of brake fitted to a trailer car on the Dresden tramways are described. A discussion followed, in which **Hefner-Alteneck** and **Klose** pointed out the reduction of the coefficient of friction at high speeds and the corresponding advantage of magnetic brakes acting by means of Foucault currents. L. B.

400. *Fall of Potential along Rail Return.* **A. Barbillion.** (Écl. Électr. 21. pp. 94–96, October 21, 1899.)—At every point of a rail conveying a current part of the current strays into the surrounding soil. Let the potential of the rail at the point $x = 0$ be V_0, and its potential at the point $x = l$ be V_1. Let, further, ρ stand for the contact resistance, per unit length of rail, between the rail and earth. The author shows that the potential V at any point x may be represented by the equation—

$$V = Ae^{x/\sqrt{\rho}} + Be^{-x/\sqrt{\rho}}$$

where A and B are two constants defined by the equations—

$$A + B = V_0$$

$$Ae^{l/\sqrt{\rho}} + Be^{-l/\sqrt{\rho}} = V_1.$$

A. H.

401. *Experiments on Rail Bonds.* **H. H. Norris.** (Street Rly. Rev. 9. pp. 582–583, September 15, 1899.)—The author deals briefly with earth resistance, and points out that this is, as a rule, sufficiently high, so that it should not be possible for any great quantity of the return current to leave the rails unless the bonds are defective. The requisites of a good bond are both mechanical and electrical. They must not be able to work loose, and they must be flexible to allow for the yield of the rails to the weight of a car, and also to allow for changes in length of rails due to temperature. The electrical conductivity must be good, with large connecting surfaces at the rails, a sufficiently high pressure between those surfaces, and no chance of oxidation of those surfaces.

A summary of tests made by Little and Reynolds is given. The method used was to take two voltmeter readings for each bond test, one between two points on the rail about 15 feet apart—being proportional to current in rail—and the other across the rail joint itself. From the results it was found that in some cases the joint resistance was less than one-third the actual bond resistance, and in other cases was more than ten times that value. The author states that these tests could best be performed by pushing the contacts rapidly along the line, a kick of the voltmeter pointer indicating the presence of a bad bond. The difficulties are: (1) to operate the device fast enough to work in with a regular schedule, (2) to make a proper note of the faulty joints, and (3) to operate with few observers.

He suggests using a recording voltmeter, the drum to be driven from a wheel running over the rail. This may be done by having a small platform suspended behind an ordinary car, having a flanged wheel running on the track to drive the voltmeter drum, and carrying at its ends the spring contacts to rest on the rail. The drum of the voltmeter may have a spiral travel, and thus a continuous and permanent record of the state of the line would be obtained. E. D. P.

402. *Accumulator Traction.* **J. Zacharias.** (Elektrotechn. Ztschr. 20. pp. 471–472, July 6, 1899.)—The paper contains some details regarding the Ghent electric tramcars, which are driven entirely by accumulators. Each car contains 12 boxes of 9 cells each, making up a total of 108 cells, the weight of which is about 2,000 kg. The capacity of the cells is sufficient for a 50–58 km. run. The normal speed in the town is 12 km., and in the suburbs up to 30 km. per hour. The charging of the cells is effected as follows: The initial charging current is 60–80 amperes, at a P.D. of 250 volts. When the current falls to 45 amperes, the P.D. is, by means of boosters, raised to 275 volts, the current rising to about 50 amperes. The charge is then continued until the current falls to 10 amperes. This method of charging is found to give the most economical results. The cells are of the Julien type, with corrugated Planté positives and negatives consisting of perforated lead cylinders packed with spongy lead. A capacity test by the author of a cell weighing 25 kg. (including acid) gave 300 ampere hours at a 15-ampere, and 250 ampere hours at a 50-ampere discharge rate. The author states that cells which had run 8,000 kilometres showed no signs of deterioration. A. H.

403. *Accumulator Trials.* **A. Bainville.** (Électricien, 18. pp. 249–253, October 14, 1899.)—Methods and results of the Automobile Club trials. Out of the large number of competitors, only four batteries had had no failure in voltage up to August 26, 1898 (*cf.* Électricien first half-year, 1899, p. 385 and 18, pp. 49 and 161). M. O'G.

404. *Weight of Accumulators for Electric Vehicles.* **J. Rosset.** (Ind. Élect. 8. pp. 386–388, September 10, 1899.)—By a series of calculations the writer of this article endeavours to determine the weights of accumulators which are necessary for an electric vehicle to accomplish a given distance. He gives an equation—

$$y = \frac{Pl}{250 - l}$$

where y represents the weight of the necessary accumulators.
P represents the weight of the vehicle with its complement of passengers.
l represents the distance travelled in kilometres.

Assuming a vehicle and passengers to weigh, say, 1,000 kilogrammes, he arrives at the following results:—

l kilometres travelled	10	20	30	40	50	60	70	80	90	100
y kilogrammes of accumulators ...	41	86	136	190	250	315	388	470	562	666

Curves are given showing the necessity (from the point of view of efficiency) of having charging stations at frequent intervals.

A case is considered of an electric vehicle going from point A to B in a given time, the distance A B being the direct route but badly paved, with a coefficient of traction of, say, 0·04. A second route, ACB, is one and a half times as long but the road is good, the coefficient of traction not exceeding 0·02. Instead of taking the direct route at, say, 8 kilometres an hour, it is therefore better to travel along ACB at 12 kilometres per hour, as the coefficient of traction increases only very slightly with the speed, and in consequence less energy is required on the longer track.

The conclusion is drawn that in the design of electrically propelled vehicles it is as important to reduce the losses in the motors, gearing, &c., as it is to reduce the weight of the cells. E. K. S.

405. *Siemens and Halske Electric Omnibus.* **Siebert.** (Elektrotechn. Ztschr. 20. pp. 671–674, September 21, 1899.)—An illustrated description of an electric omnibus to carry 16 passengers. The omnibus is fitted with four motors, each giving 4 H.P. with 350 volts when running at 550 revolutions per minute. Hagen accumulators are used, there being 200 cells weighing 1,500 kilogrammes. The total weight of the omnibus complete is 6,500 kilogrammes. Particulars of a test made on April 21 (1899) are given. E. K. S.

406. *Electric Waggon.* **M. Schiemann.** (Deutsche Zeitschr. Elektrotechn. 6. pp. 104–107, July 1, 1899.)—Description of an electric waggon propelled by accumulators. The motor, by Kummer and Co., gives 8 H.P. at 80 volts and 1,500 revolutions, at which speed the waggon travels on the level at 7 kilometres per hour. The weight of the complete waggon, inclusive of the accumulators, is 4,227 kilogrammes, the battery alone weighing 1,400 kilogrammes. The number of the cells is 44, so that they can be charged from any 100 or 110 volt circuit. Some particulars of the power taken when travelling over different kinds of road surface are given. E. K. S.

407. *Signalling on Tramways.* (Elect. Engin. 24. pp. 454–455, October 13, 1899.)—Owing to numerous curves at Dover, much delay used to be caused by cars waiting for one another unnecessarily at turn-outs. Signalling pillars were therefore erected at suitable points. When the car passes a pillar, the conductor presses a switch which sets at "danger" or "line clear" the signal arm in that pillar as well as in the next pillar in front or behind. The arms are moved by a polarised armature between electromagnets. Since signalling was adopted, each car is enabled to make two complete trips a day more than before, *i.e.*, an extra profit of £1 per car per week. The financial results of the Dover tramways for the year ending March, 1899, are given. The expenses per car mile were 9·06d., and the receipts 10·92d. The energy used amounted to 0·98 units per car mile.
E. H. C.-H.

408. *Signalling-System for Tram-Cars.* **H. B. Rogers.** (Street Rly. Rev. 9. pp. 387–388, June 15, 1899.)—The system comprises rail contacts, signal boxes, signal lamps, and semaphores for street railways. The principal feature of the system is the rail contact-box. A steel tongue, or spring, is pivoted at one end to the web of the rail; the free end carries a plunger which works in one arm of a U-tube containing mercury. When the plunger descends under the weight of a passing car, the mercury in the second arm of the U-tube rises and makes contact with a metallic point connected to the semaphore apparatus. In frosty weather the space under the plunger was filled with salt; they were never frozen. No trouble from rain-water was experienced; the mercury made an effective water-tight joint. R. A.

409. *Magnetic System of Railway Signalling.* **W. S. Boult.** (Elect. Rev. 45. pp. 491–494, September 22nd, 536–537, September 29th, and 573–574, October 6th, 1899. A paper read before the British Association.)—The defects of the present system of semaphore, lamp, and detonator signalling are discussed and the requirements of a perfect system enumerated. All visual

systems are undesirable, owing to the necessity of signalling in three ways—one for daytime, one for night-time, and a third for fog. Mechanical or electrical methods are liable to damage.

The only method of meeting the requirements at all satisfactorily is by means of electromagnetic signals. The details of such a system are figured and described. The signals are transmitted from electromagnets lying between the rails to a pivoted polarised needle carried below the engine, which closes one of two relay circuits. Thus two signals can be given instead of one as in the present system. The signals are recorded by a small indicator instrument in the locomotive cab having two small semaphore arms on the face. The relay is operated by either of two batteries. A defect in either battery circuit is immediately indicated by a coloured spot on the indicator face, and signalling continues by means of the other battery. At a junction the line open is indicated by numbers on the indicator face. Arrangements can be made for telling the driver which of eleven alternative lines is offered. Just before reaching a signalling point a set of permanent magnets put the semaphores to danger. When home or distant danger signals are passed different bells are thrown into circuit, which continue ringing until stopped by the driver employing a special "relay push." By automatic switching the current is allowed to flow only while a train is on the block. The method is also adapted to an automatic block system. As to costs, the author estimates that the upkeep per annum would not exceed the extra expenses incurred on one line in "fogging" alone during five days of fog in 1888, viz., 58s. per post. Reliability of action has been tested by fitting a Great Northern Railway express engine with an early form of the apparatus, by which signals were taken perfectly at a speed of 70 miles per hour. A discussion followed. L. B.

410. *Automatic Block System.* (Elektrotechn. Ztschr. 20. pp. 531–532, July 27, 1899.)—The Austrian State Railway has recently introduced a modified form of the Siemens' automatic block-system for the Waidhofen-Oberland and Reifling-Selzthal lines. It is intended to operate so as to ensure safety to the trains both on the section immediately in front and the section immediately behind a particular train. A diagram is given, showing the electrical connections and the general arrangement of switches. R. A.

411. *Wind Power Electric Lighting System.* **E. Dick.** (Zeitschr. Elektrotechn., Wien. 17. pp. 403–407, July 23, and 423–426, July 30, 1899.)—This is a description of the details of a system installed by Wuste and Rupprecht, of Vienna, for a private electric lighting plant driven by wind power, with the necessary storage and switching arrangements. The windmill itself is not described. The plant is designed for a wind velocity of 9 to 16 miles per hour. Owing to the unreliability of the driving power, two batteries are installed, each capable of supplying one evening's load. The switching and regulating gear is almost entirely automatic. The voltage is regulated at 90, and the dynamo switched out of circuit as soon as it falls below this. The batteries and switching apparatus are installed in the house to be lighted, the dynamo in the most suitable spot for driving. In the daytime the batteries are charged in parallel, and each is automatically switched out of circuit when the voltage of each cell rises to 2·5 volts. At night one of the batteries is connected in parallel with the dynamo to the lamp circuit to regulate the voltage, the other being connected to take any surplus power as a charging current. The next night the functions of the two batteries are reversed. This reversal, which is the only non-automatic part of the switching gear, is carried out by the same switch which puts the lamps in and out of circuit. When the wind falls both batteries are paralleled on the lighting circuit. The change from charge to discharge is made by putting small resistances in series with the battery. There is no end cell regulation. Fully illustrated details are given of the necessary apparatus, and a mathematical explanation of the method of automatic operation. L. B.

412. *Electric Train Lighting.* **Auvert.** (Écl. Électr. 20. pp. 460–465, September 23, 1899. Abstract of an article in the Revue Générale des Chemins de Fer, 22. p. 57, August, 1899. Also Zeitschr. Elektrotechn., Wien. 17. pp. 587–589, November 19, 1899.)—The various systems hitherto employed for train lighting by electricity are noticed. The author then describes a new system which is being employed experimentally by the Cie. P.L.M. of France. It resembles the Stone system in having a dynamo and battery on each car, but the method of regulation is unique. The dynamo is driven by a friction wheel from the inside face of a carriage wheel, and its speed varies with that of the train. It is excited by a constant current from the battery, which also feeds the lamps when the speed is too slow. As the speed rises an automatic switch throws the dynamo into parallel with the battery. A commutating device changes over the dynamo connections if the direction of the train's motion be reversed. The current in the main circuit is regulated to a constant maximum value by being passed through a small series wound motor, whose spindle carries a brake pulley and brake whose pressure can be adjusted. If the dynamo current rises above a certain maximum value the motor overcomes the resistance of the brake and rotates, introducing the necessary back E.M.F. to keep the current constant. This maximum current is sufficient to feed the lights and charge the battery. As the speed falls the charging current first falls, then becomes a discharge, and at a lower speed still the dynamo is automatically cut out and the whole current supplied from the battery. The lamps can be "turned down" by putting two in series, a compensating resistance being put in parallel to keep the load steady. The carriage is lit by thirteen 9-c.p. lamps taking 1·22 amperes each at 15 volts, 16 amperes in all. The regulating motor brake is adjusted to give a constant maximum current of 28 amperes, the remaining 12 going to charge the battery, which has a capacity of 180 ampere hours. It consists of eight cells, weighing in all 460 lbs., and is able to supply the lights without the aid of the dynamo for eight or nine hours. The experimental carriage has been in constant service since March, 1899, having completed 18,000 miles satisfactorily. In a complete train only one dynamo in the brake van need be employed, with a battery and switching gear on each carriage.
L. B.

413. *Electric Train Lighting.* (Engineer, 88. pp. 46–47, July 14, 1899.)—The latest design of the Stone system is described, as used on the Metropolitan Railway. Blinking of the lamps when the automatic switch cuts out the dynamo is avoided by feeding the lamps through a resistance when running and cutting this out when the train comes to a standstill, thus compensating for the lowered pressure of the battery. Other improvements are explained, with illustrations. (See also 1899, Abstract No. 890.) A. H. A.

414. *Arc Lamps.* **H. Görges** and **Queisser.** (Elektrotechn. Ztschr. 20. pp. 444–449, June 22, 1899. Paper read before the Elektrotechn. Verein,

Berlin.)—The advantages of differential over shunt regulated arc lamps are pointed out. Characteristic curves for each type of lamp are given, showing the effects of variations of the terminal voltage and the sensibility of the regulating mechanism. These variations are also worked out mathematically, and the differential coefficients are obtained for the current consumed and the light emitted with respect to the other variables. These show much smaller values for the differential than for the shunt lamp.

The new differential focussing arc lamp of Siemens and Halske (German patent 101050, 1898) is fully described, as well as the methods of adapting it to various conditions of service. With good lamps and a steady voltage, three lamps can be run in series between the 110 volt constant potential mains. Complete tests are given of 9 ampere lamps running two in series with 46 volts across the lamp terminals, and three in series with 35 volts. The watts consumed in the lamps per mean spherical candle-power are 0·59 and 0·66 in the two cases respectively in favour of the higher voltage lamp. But the power that has to be dissipated in resistance in the former case balances this difference in efficiency, and causes the total light obtained to be practically the same, viz., 1,400 c.p. A discussion followed. (See also 1899, Abstract No. 1823.) L. B.

415. *Enclosed Arc Lamps.* **W. A. Turbayne.** (Canad. Elect. News, 9. pp. 159–160, July, 1899.)—In this article the theory and practice of the working of enclosed arc lamps are clearly explained, and the running cost compared with that of open arc lamps. A. H. A.

416. *Theatre Lighting.* (*Covent Garden.*) (Elect. Engin. 23. pp. 558–564, 1899.)—Lamps of white, blue, red, and amber glass are carried in battens of oak and iron, 40 feet long, arranged vertically and horizontally; the oak is grooved to carry the cables, and is supported on steel lattice-work. Special boxes are made for connecting the cables and for switching on the wing lights. In an elaborate switch-room control is given by means of liquid regulating resistances. Diagrams of float, battens, and hand-wheel controllers are given. M. O'G.

417. *Incandescent Lamp and Transformer Construction in America.* **H. E. P. Cottrell.** (Engineer, 88. pp. 364–366, October 13, and pp. 387–388, October 20, 1899.)—The author remarks that comparatively few of the ever-increasing number of incandescent lamps manufactured attain the standard of even moderate efficiency, and fewer still approach the ideal where the "curve of candle-power" could be represented by two parallel horizontal lines throughout the whole life of the lamp.

Definitions and curves are given of "specific efficiency" and "total luminous efficiency" of incandescent lamps. It is pointed out that the lamp which maintains throughout its life the highest average interval between the candle-power and watts per candle curve, is the most effective for lighting purposes, so that the average specific efficiency, and not the length of life, is what should be principally considered in selecting a lamp.

Life alone, apart from candle-power and efficiency, is of small importance, and at the present low price of lamps even doubling the number of lamp renewals will add only a small percentage to the general cost of lighting, while it is possible, by the judicious choice of lamps, to increase the lighting efficiency by as much as 40 or 50 per cent. With regard to the effective illumination or "candleage" of a lamp, as this varies considerably in different directions, it should be determined while they are rapidly revolved and their rating made to accurately correspond with the actual average illumination of the whole horizontal plane and not with one or more selected points in that plane. The factors which determine the "candleage" of a lamp are (1) the quality and shape of the filaments; (2) the character of the vacuum; (3) the quality of the glass; and (4) the regulation of the pressure at which it is kept lighted.

There is very little difference in the system of looping in the various makes of incandescent lamps, or in the materials of which the filaments are composed, or in the process of carbonisation. There is also but little difference in the dimensions given to the filaments, so that, approximately, filaments of equal capacity of different makes should possess equal illuminating powers if the quality of their surfaces is uniform.

The character of the vacuum surrounding the filaments is almost as important as the quality of the filaments themselves in determining the candleage of a lamp, more especially in high-voltage lamps. The character of the glass of which the bulbs are made affects the candleage of a lamp to a very serious extent, the best glass intercepts as much as 10 per cent. of the illuminating power, and inferior glass double that amount, even when perfectly clear and colourless.

A table is given of the standard dimensions of some of the best proportioned bulbs for various purposes and uses, which are made from Corning glass, which does not intercept more than 6 or 8 per cent. of the total photometric radiance.

The wattage of small high-voltage lamps per candle is not so low as that of lamps of lower voltages, and their specific efficiency not so good; whereas a 16-candle 110 volt lamp will consume about 3·1 watts per candle, a similar lamp for 220 volts will consume 3·8 watts per candle-power, the specific efficiency of the first being 0·323, and of the second only 0·263, and the length of life is also proportionately shorter.

Transformers.—The efficiency of transformers depends on the perfection and arrangement of the following details of their construction: (1) Insulation. (2) Mechanical protection. (3) Regulation. (4) Character of core metal and consequent amount of hysteresis. (5) Arrangement of coils and consequent amount of impedance.

There are two distinct types of transformers in use. The "shell" type which is the more recent of the two, is said to be cheaper to manufacture. It however, possesses inherent disadvantages, the chief ones being weak insulation and increased impedance arising from the overheating of the coils due to their being buried in the iron, together with increased hysteresis owing to the iron being relatively cooled. The other type is known as the "core" type and is being more and more adopted in all recent installations.

The author advocates that the insulation between the primary and secondary of the transformer should be subjected to a disruptive test in the factory of at least 10,000 volts, the transformer itself being subjected momentarily to double, treble, or even quadruple the working pressure.

In order that the insulation of the transformer should last, the coils should be firmly fixed to the cores and the latter to the cases, so that their relative position cannot alter. With regard to core losses, the only practical way of avoiding initial hysteresis and its progressive increase, through the so-called "ageing of the iron," amounting in some cases to 50 per cent. and 100 per cent. of the original core loss after a few months' use, is to ensure uniformity of texture in the cores by building them up of thin discs of carefully selected metal, these discs being insulated by japanning and joined by strips —three, four, or five in number—along the edges. The width of the gap between the discs is shown by experiment to have no effect upon the efficiency of the cores made from them, and in practice the discs are pressed together as close as possible, so that the gaps composed of japanning are reduced to a minimum thickness. In cores constructed in this way the initial hysteresis is very small, and there is practically no sensible ageing.

Diagrams are given showing the connections to be employed in transformer testing.

The principles governing transformer use in modern stations can be briefly summarised as follows :—

(1) The station voltage should be regulated so that all lamp circuits at the average load can be run at normal pressure. (2) All transformers should be connected with secondary mains serving districts of a maximum area. (3) All transformers should be subjected to periodical and frequent tests, independent of guarantee or reputed performance. (4) The hours of load on each transformer should be increased to a maximum. (5) The total transformer capacity required to carry a given total station load should be reduced to a minimum. (6) Transformer regulation at a frequency of 60 periods should be maintained within limits of 2½ per cent. and defects from this cause at average loads should not exceed 1 to 1½ per cent., the percentage of increase with higher frequencies being maintained as low as possible. (7) Core losses at 60 frequency should not exceed 2 per cent. for 2,000 watts capacity, 1½ for 5,000 watts, and 1 for 15,000, and so on, the proportion of loss diminishing with higher frequencies. L. J. S.

418. *Berrenberg Lamp Factory.* (Electrician, 44. pp. 35–38, November 3, 1899.)—The chief feature of the Berrenberg lamp is that the vacuum is produced by a mechanical pump in which all joints, valves, &c., are enclosed in a vacuum jacket which is maintained by a second pump producing a rough vacuum. It is claimed that the absence of mercury vapour in the lamp prevents the blackening of the bulb after use. This paper gives a description, with illustrations, of the works recently erected by the Berrenberg Electric Lamp Syndicate. The works are capable of turning out 40,000 lamps per week. The paper also gives two diagrams of curves which show that the candle-power of a 16-c.p. lamp falls to 13 c.p. at the end of 1,000 hours, while the watts per c.p. rise from 2·4 to 3·0 in the same time. E. C. R.

419. *Electric and Gas Lamps.* **S. A. Rumi.** (Rivista Sci. Industriale, 31 pp. 139–143, June 30, 1899. From the "Giornale Scientifico" di Palmero No. 4, 1899.)—The author compares the electric incandescent lamp with the Auer (incandescent) gas lamp. In point of economy in illumination the latter is superior, but the life of a gas mantle is considerably less than that of an electric incandescent lamp. Figures are given showing the percentage loss of candle-power of two English and three German mantles, after burning 100 and 500 hours; the means of these are respectively 15 per cent. and 45 per cent. Voelher found a loss of 50 per cent. in the light of two English mantles after 250 hours. Massa, the inspector of the street lighting in Genoa, finds that the life of different mantles of the same type is exceedingly variable.

For the loss of light in electric lamps the author gives 20 per cent. after 500 hours as a practical figure, taking perfect and faulty lamps together.

G. H. B.

REFERENCES.

420. *Development of Electric Stations.* **A. D. Adams.** (Cassier, 17. pp. 91–103, December, 1899.)—The author deals in general terms with the development of electricity supply stations from their commencement up to the present day. The advantages gained by modern introductions are pointed out, examples of present-day stations and several illustrations of typical generating works and substations are given. E. D. P.

421. *Single-Phase Distribution.* **H. A. Wagner.** (Elect. Rev. N.Y. 34. p. 343, 1899. Abstract of a paper read before the National Electric Light Association, New York, May 24, 1899.)—This is an introductory article on the relative merits of the single-phase and three-phase alternating currents for combined distribution of light and power. W. G. R.

422. *Generators and Polyphase Plant of Chicago Edison Company.* **H. E. Niesz.** (Amer. Electn. 11. pp. 445–451, October, 1899.)—A fully illustrated and lengthy article dealing, in detail, with the direct-current, three-phase generators, and the regulating apparatus, &c., connected therewith, of the Chicago Edison Company. E. D. P.

423. *An 83-mile Electric Power Transmission Plant.* **J. A. Lighthipe.** (Cassier, 17. pp. 3–13, November, 1899.)—Illustrated description of the Southern California Power Company's power stations and transmission line to Los Angeles (See 1899, Abstract No. 923.)

424. *Electric Traction Data.* **H. J. Ryan.** (Street Rly. Rev. 9. pp. 580–582, September 15, 1899.)—Data of equipment and working of eight street railway plants.

425. *Financial Data of Traction Systems.* **E. E. Higgins.** (Street Rly. Journ. 15. pp. 680–684, October, 1899.)—The systems referred to are in various parts of the world.

426. *Accumulators for Electromobiles.* **(E. C. Rimington.** (Automotor Journal, 3. pp. 493–494, July; pp. 598–600, September; 4. pp. 18–19, October; and pp. 61–63, November, 1899.)

427. *Control of Electric Vehicles.* **E. H. Cozens-Hardy.** (Automotor Journal, 3. pp. 495–496, July; pp. 608–609, September; and 4. p. 32, October, 1899.)

428. *Electric Railway and Tramway Carriage Works, Limited, Preston.* **B. Sykes.** (Elect. Engin. 24. pp. 587–591, November 10, 1899.)

429. *Train Service and its Practical Application.* **I. A. McCormack.** (Street Rly. Journ. 15. pp. 790–795, November, 1899.)—Paper read before the American Street Railway Association at Chicago.

430. *Car Mileage.* **H. C. Mackay.** (Street. Rly. Journ 15. pp. 797–799, November, 1899.—Paper read before the American Street Railway Association at New York.)—Discussion of suitable units for comparison of traction systems.

431. *Care of Car Equipment.* **J. H. V. Veer.** (Street Rly. Journ. 15. pp. 796–797, November, 1899.)—Read before the Amer. St. Railway Association.

432. *Construction and Maintenance of Steel Railway Tracks.* **E. Butts.** (Street Rly. Journ. 15. pp. 795–796, November, 1899. Paper read before the American Street Railway Association at Chicago.)—Opinions on track construction, and illustrations of Kansas City track. J. T. R.

TELEGRAPHY AND TELEPHONY.

433. *Pollak-Virag Machine Telegraph.* (Elect. World and Engineer, 34. pp. 84–85, July 15, 1899.)—The merit of the system is its high speed. The messages are perforated on a strip of paper which passes under two small brushes connected to the reverse poles of two separate batteries. The paper slip is moved along by means of a cylinder which is connected to the circuit and makes contact with the brushes above it whenever there is a hole in the paper strip. In this way positive or negative currents will be sent over the line according to which one of the brushes comes in contact with the cylinder. The paper strip has two rows of perforations, the one serving for the positive current impulses, the other for the negative ones. The one impulse produces at the receiving station a line going upward corresponding to the dash in the Morse code, while the other impulse produces downward strokes, corresponding to the dots in the Morse code. The receiving apparatus is a telephone disc provided with an oscillating mirror which makes a photographic record of its motion on a revolving cylinder. The period of the forced oscillations is made to coincide with the natural vibration of the mirror by means of a condenser, and an inductance is mounted in parallel with the transmitting apparatus to balance that of the telegraph circuit. As many as 100,000 words have been transmitted per hour with a working pressure of 25 volts. E. E. F.

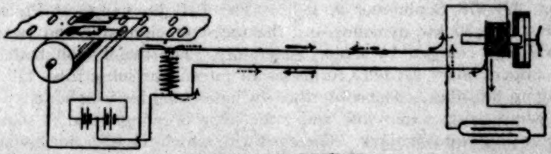


DIAGRAM OF CIRCUITS.

434. *Simultaneous Telegraphy and Telephony.* **H. S. Webb.** (Amer. Electn. 11. pp. 420–423, September, 1899.)—The reason why an inductance and capacity retard the rise and fall of the dot-and-dash current is given. To prevent a Morse current affecting a telephone, it is connected in series with a condenser which intercepts continuous currents, but not the alternating current for the telephone. To ensure telephone currents reaching the receiver and not going to ground through the telegraph, a 500-ohm inductance coil is put in series with the telegraph relay. An illustrated description of the method of construction of the coil and condenser is given. M. O'G.

435. *Compensating Condensers in Telegraph Circuits.* **M. G. Simpson.** (Electrician, 43. pp. 635–636, August 25, 1899.)—By equating the instantaneous values of the currents a short time after interrupting the circuits of a condenser and an inductive resistance, the capacity of the condenser required by any given relay having self-induction is calculated. This is modified in the case of an actual line by the preponderance of its capacity. A practical case is worked out. M. O'G.

436. *Resistance of Earth Plates.* **R. Nowotny.** (Zeitschr. Elektrotechn., Wien. 17. pp. 445–446, August 20, 1899.)—The results of tests of the resistance of various earth connections by Wiechert's method, carried out by the German Telegraph Department, are given, and the effect of the material of the subsidiary earth plate employed on the results is discussed. L. B.

437. *Wireless Telegraphy.* **J. L. Adams, Jr.** (Elect. World and Engineer, 34. pp. 273–274, August 19, 1899.)—Further experiments on self-inductance in a receiving circuit with coherer. Three or four 8 c.p. 104 volt lamps in series with a coherer have the same effect on the latter as an inductive resistance of 5,000 ohms, *i.e.*, they stop all action in the coherer. A touch from the positive wire of a 200 volt direct current circuit causes a coherer to respond instantly. Horizontal slits were found to cut off all effects from vertical antennæ. M. O'G.

438. *Storage Battery in Telephone Exchanges.* (Elect. World and Engineer, 34. pp. 377–378, September 9, 1899.)—The Bell Exchange at Philadelphia employs two 30 kw. dynamos, and the four-volt, eight-volt, and twenty-volt batteries are charged by motor generators. The twenty-volt battery, with 1,000 ampere hours' capacity, furnishes all current for subscribers talking and calling up the office. The subscriber, by unhooking his telephone, operates a relay which works a four-volt lamp ; the lamp is extinguished as soon as the operator plugs into the jack. The cord with which the operator connects the calling subscriber to his listener is wired to the twenty-volt battery. M. O G.

439. *Telephone Exchange Patents.* (Elect. World and Engineer, 34. pp. 378–379, September 9, 1899.) (See Science Abstracts, 1899, No. 1313.)—C. Scribner, in a patent dated August 29, 1899, uses polarised individual annunciators with a battery introduced in the connecting device, so that when two lines are connected the annunciator will not act. This inventor would dispense with spring-jack switches and avoid the use of test wires in multiple systems. In a second patent issued August 29, 1899, he shunts the annunciator and incidentally provides a new test system which uses a buzzer to detect whether an annunciator coil is or is not shunted and the line therefore in use. M. O'G.

440. *Automatic Telephone Exchange at Augusta, Ga.* **L. Campbell.** (Elect. World and Engineer, 34. pp. 301–302, August 26, 1899.)—An illustrated description of this automatic telephone exchange. A complete copper metallic circuit is used and storage batteries furnish energy to operate the machines, which are grouped on a central switchboard to the number of one thousand. One inspector and two assistants look after the whole system.

The method of calling any number is to turn a dial on the instrument; thus, for No. 637 the dial is first turned to 6, then to 3, and then to 7, and direct communication is then obtained with 637. If on turning the magnetic crank the subscriber's own bell does not ring the number wanted is engaged. Absolute privacy is claimed. M. O'G.

441. *Charleroi Installation.* **E. Piérard.** (Électricien, 18. pp. 129–132, August 26, 1899.)—Description of a central exchange for 1,200 subscribers. Overhead wires alone are used—the insulators on the turret are only 17 to 20 centimetres apart, yet no contacts occur—"Standard" boards are used. The indicators are reset automatically, and the current used for this purpose is cut off by the automatic action, thus effecting considerable economy. M. O'G.